UME 54 NUMBER 3 . . . ONE YEAR FOUR DOLLARS

Illinois U. Library

GENERAL ELECTRIC Review

TABLE OF CONTENTS
Page Three

March 1951

HERMETICALLY SEALED

SOLA *Constant Voltage* TRANSFORMERS

FOR USE ON MIL-T AND JAN PROJECTS

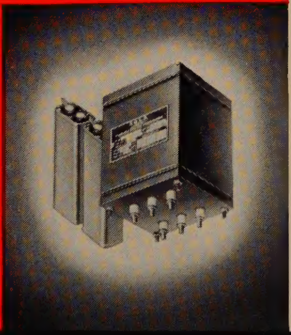
The patented SOLA Constant Voltage Principle provides the following advantages over ordinary transformer design: regulation within ±1% with total primary variations as great as 30% . . . automatic, instantaneous regulation . . . freedom from moving parts, maintenance and manual adjustments . . . self-protection against short circuit. They are available in a complete range of capacities and special types (such as frequency compensated or with harmonic filter).

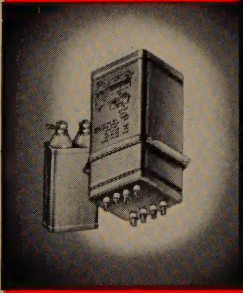
Today's complex electrical and electronic defense equipment requires unfailing accuracy and dependability under extreme conditions of humidity, heat, mechanical shock and other adverse conditions. To meet those needs SOLA voltage regulators can be provided in hermetically sealed housings which conform to defense specifications for grades 1, 2 or 3 hermetic sealing. Splash proof design housings are provided for large units where hermetic sealing is not feasible.

SOLA Constant Voltage Transformers were widely employed during World War II wherever continuous precision performance of electrical and electronic units was mandatory. Typical defense applications include: observation and fire-control, radar, omni-directional ranges and other navigation aids, X-ray equipment, flight and navigation trainers, and photoelectric devices.

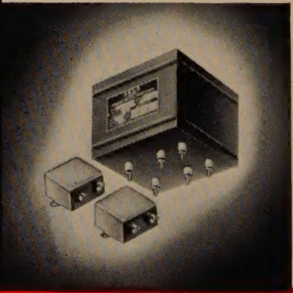
Often the precise voltage input upon which a device's design was predicated is not available. Yet, input voltage level must continuously meet design requirements for satisfactory performance. You can guarantee optimum performance for your unit by stabilizing input voltage with a SOLA Constant Voltage Transformer.

SOLA Constant Voltage Transformers are made under one or more of the following Patents: 2,143,745; 2,212,198; 2,346,621.





Typical types of Hermetically Sealed SOLA Constant Voltage Transformers



The engineers and sales representatives of the SOLA Electric Company will be glad to discuss the application of SOLA Constant Voltage Transformers to your specific requirements. Your phone call or letter will receive our prompt attention.

SOLA *Constant Voltage* **TRANSFORMERS**

Transformers for: Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs
Oil Burner Ignition • X-Ray • Power • Controls • Signal Systems • etc. • **SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois**

GENERAL ELECTRIC Review

MARCH, 1951
Vol. 54, No. 3

EVERETT S. LEE
Editor

R. E. MAY
Circulation and
Advertising Manager

J. E. GLICK
Associate Editor

THE COVER

limpse of accelerated-life-test facilities in the luction of watthour meters. Watthour meters long been among the most precise measuring ces in common use; and few commodities sold y are more accurately measured than electrical gy. Through the benefits of new designs, new erials, and new manufacturing techniques, ining the application of exacting quality-control edures, certification of accuracy and perform- has been made possible. Significant elements ing to this recent advance are presented this th in the article on page 10.

ADVERTISING INDEX

Maze Corp.............48
rican Brass Co.............31
əex Electric Corp.............55
conda Copper Mining Co.............31

ish Thomson-Houston Co., Ltd.............30

ıbridge Thermionic Corp.............46
adian General Electric Co., Ltd.............55
ostat Manufacturing Co., Inc.............30
ıell-Dubilier Electric Corp.............54

en Co.............3d cover
rer-Harris Co.............52

on-Swan Electric Co., Ltd.............30

uson Pailin Limited.............30

eral Electric Co. . 4, 6, 25, 47, 50, 55, 56, 4th cover

point Electric Appliance Co., Ltd.............30

Copper Tube & Products, Inc.............47
rsoll-Rand Co.............5

oratory Furniture Co., Inc.............1

lory and Co., Inc., P.R.............16
ropolitan-Vickers Electrical Co., Ltd.............30
ropolitan-Vickers-GRS Ltd.............30
iature Precision Bearings, Inc.............30

Departure—Div. General Motors Corp.............45
Hermes, Inc.............40
ton Victor Ltd.............30

ite Manufacturing Co.............2
ns-Corning Fiberglas Corp.............49

on Can Co., Inc.............35
Industries, Inc.............22
Electric Co.............2d cover
r Carbon Co.............26
gue Electric Co.............7

pil Corp.............53

Virginia Pulp & Paper Co.............46

EDITORIAL CONTENTS

FRONTISPIECE: Everett S. Lee, Editor 8

EDITORIAL: To Engineers Everywhere 9

ARTICLES:

Watthour-meter Certification . F. H. Busch and J. C. Garrett 10
The design, manufacture, and testing of watthour meters are carried out with such precision and reliability that it is now feasible to certify accuracy and performance

Gas-turbine Power Plant Completes Year and a Half of Operation . . . . B. G. Hatch 17
Simple-cycle plant installed at the Belle Isle Station of the Oklahoma Gas & Electric Company, the first in commercial power-station service, gives a good performance record

A Résumé of the Gas Turbine-electric Locomotive . . . A. H. Morey 23
Results and evaluation of the newest form of rail motive power after a year and a half of test in freight service. Ten units have been ordered for regular commercial use

Outdoor Plant Lighting . . . . J. S. Lindsay 27
Outdoor plant lighting technique as a vital factor in minimizing waste and increasing manufacturing efficiency in today's program of sharply accelerated production schedules

Industrial Uses of Ultrasonics . . . . G. E. Henry 32
Many different applications of sound energy to industrial purposes have been attempted, and even more proposed. Here are some of the possible fields of application, with special attention to its use for the industrial cleaning of metal parts

Corrosion Control for Cooling Systems of Electric Apparatus . . . Emil J. Remscheid 36
A positive yet economical means of preventing a corrosion problem, particularly applicable where iron is present in a cooling system in which water is used as the coolant

DEPARTMENTS:

High Lights and Side Lights . 41
New Products 43
Trade Literature . . 46
Book Reviews . . 47
Library Notes . . 53

INDEXED: By the Industrial Arts Index; the Engineering Index; and Science Abstracts

Editorial Advisory Board: H. A. WINNE, Chairman • H. L. ANDREWS
Dr. W. R. G. BAKER • W. C. BROWN • H. V. ERBEN

ADVERTISEMENTS: The statements and claims presented are those of the advertisers, and their publication does not imply endorsement by the REVIEW.

ADVERTISING DEPARTMENT: General Electric Review, Schenectady 5, New York.
CIRCULATION DEPARTMENT: General Electric Review, Schenectady 5, New York.
SUBSCRIPTION RATES: *Payable in advance.* United States and Possessions, and countries in Pan-American Postal Union, one year $4.00, two years $6.50, three years $8.00. Canada, add $1.00 to above rates. Other foreign countries, add $2.00. Public and college libraries, professors, and enrolled students deduct $1.00 from above rates. SINGLE COPY 40¢.
CHANGE OF ADDRESS: Give old and new addresses. Notices received before the fifteenth of the month will be effective with the next issue.

Entered as second-class matter, March 26, 1912, at the post office at Schenectady, N. Y., under Act of March 3, 1879. Published monthly by General Electric Company, 1 River Road, Schenectady 5, N. Y. Printed in U. S. A. *Copyright 1951 by General Electric Company.*

From Any Angle, You Can Easily Rea

SHADOW-PROOF INSTRUMENTS

Here are new General Electric switchboard instruments you can *read*—always. From greater distances and greater angles, you can take measurements quickly and accurately. Mount these instruments wherever you desire—without fear of errors when taking readings.

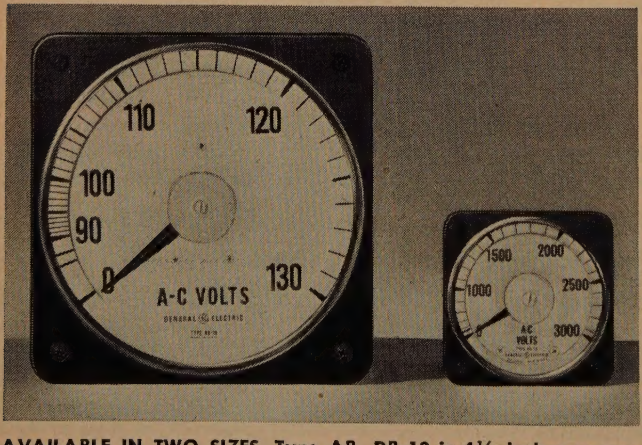
NEW IMPROVED DIAL

The dial is set forward, flush with the front of the case. A protruding convex-type glass front provides clear illumination from any angle. Result: no more cover overhang; no more shadows caused by overhead lighting. Even when the lighting angle is sharp, you can easily read these instruments.

8 DIFFERENT TYPES

You can obtain General Electric shadow-proof instruments as ammeters, voltmeters, and wattmeters; frequency and power-factor meters; temperature indicators and synchroscopes.

Compare these with other makes; then specify G-E switchboard instruments. Ask your G-E representative for more information or write for bulletin GEC-218B; Sec. 602-197, *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

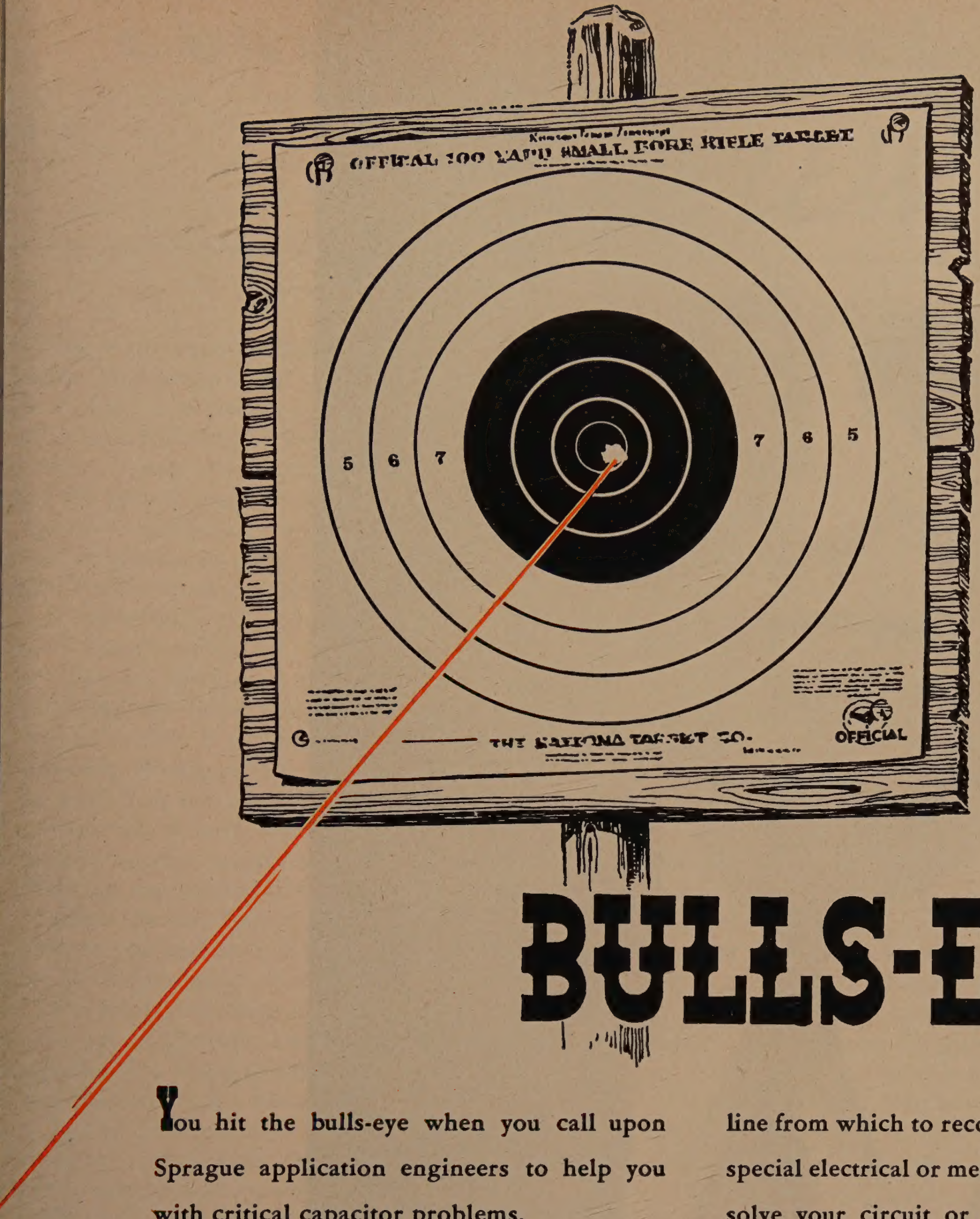


AVAILABLE IN TWO SIZES. Type AB, DB-18 is 4¼ inches square, 250-degree scale, 7.1 inches long. Type AB, DB-16 is 8¾ inches square, 250-degree scale, 14.2 inches long. Both have 1% accuracy.

SPECIFY G-E INSTRUMENTS. Whenever you use them—whether for c
trol stations, testing devices, or other installations—General Ele
long-scale shadow-proof instruments can easily be read from any an

GENERAL ELECTRIC

602-197


OFFICIAL 100 YARD SMALL BORE RIFLE TARGET
5 6 7
7 6 5
THE NATIONAL TARGET CO.
OFFICIAL

BULLS-EYE!

You hit the bulls-eye when you call upon Sprague application engineers to help you with critical capacitor problems.

Skilled in applying the essentials of capacitor design to save space and cost in complex military and civilian electronic equipment, Sprague engineers are ready to serve you.

If standard capacitors can solve your problem, they have the industry's most complete line from which to recommend. If you need a special electrical or mechanical design to best solve your circuit or production problems, they will gladly work out the details without cost or obligation.

Time is of the essence today. If you have a capacitor, interference filter, or pulse network problem, contact SPRAGUE by 'phone, wire, or mail without delay.

SPRAGUE®

SPRAGUE ELECTRIC COMPANY
NORTH ADAMS, MASSACHUSETTS

PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT

EVERETT S. LEE, EDITOR

His first editorial is dedicated to the strength of our great engineering profession

GENERAL ELECTRIC Review

l. 54
. 3

MARCH
1951

TO ENGINEERS EVERYWHERE

WELL know the uncertainties of the times. Small wonder that many of our young people are confused l undecided. I remember in my year as president of American Institute of Electrical Engineers, 1948–9, when I was privileged to speak with the engi- ring students in many of our student branches, that figures of prediction then indicated a surplus of ineering graduates, some 14,000 in 1949 and 25,000 1950. The students were greatly concerned—perhaps rried is a better word—as to what would happen to m. To them I replied—

> "You are young men of great privilege. You are receiving the finest education within the power of man to give. It provides for you an open sesame not only to engineering fields but to other fields as well. You can evaluate yourselves high in the powers you possess. Use them as they have been used by so many others who have gone before you. With an engineering education you are equipped to make the very best of yourselves, and for great good to you and to your fellow men."

Then that same year, an eminent engineer said to , "I am fearful for these engineering students, that y may not all find jobs. I sometimes think we should suade them to study in other fields." But I advised n no; that when, by nature, the student was pro- ent in the fundamentals of engineering and, by ironment, had brought these into prominence, he uld be encouraged to continue in his education; for world needed him in engineering achievement, and would overcome, surplus or no surplus.

Now, in these few years, the shoe is on the other foot. e predictions are now that there will be a shortage of ineering graduates—and there already is. But we st not let this be. It is essential to our national posi- n, yes, our world position today, that there be a tinuous flow of new engineering talent into the ad field of production just as there always has been maintain and broaden the great industrial strength ich we as a nation possess.

Many are already at work to maintain this flow. The gineering Manpower Commission of the Engineers nt Council is alert and is mustering to do a job. tor George Stetson describes much of this project in *chanical Engineering* for February 1951. Editor arles Rich carries Prof. Hollister's stirring appeal in *ctrical Engineering* for February 1951. I trust that editors of all our engineering societies' publications l of our trade journals will feature this work. I see Philip Swain has already referred to this project editorially in the February 1951 issue of *Power*. So every engineer can alert himself to what is being done.

But this is not enough. We must recognize our duty to convey to the boys in the high schools throughout our land an understanding of the satisfactions, the successes, and the honors of engineering, so that those who possess the qualifications will continue to work with determination to obtain their education in its entirety, to fortify and to undergird with technical strength our great national position.

This is a job nation-wide. Every city, every town, every village must be included. Every present engineer can help—he must help. From the well-known groups for this work, such as in Detroit or Cincinnati, to the community where there may be only a single engineer, this work must be done. Will each one in whatever community he is, advance this work with his fellow engineers either as leader or helper or guide, and start to do it today—right now.

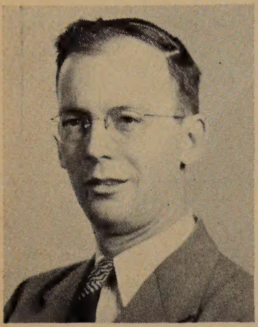
You will find the students eager to have your counsel. Encourage them to hold tight to that which is dear with a determination to get their engineering education in its entirety, broken though it may be in course. Many students will probably be enlisted variously for the defense. But through it all they must maintain their interest in their education. Groups of present engineers who live near cantonments and training fields where students may be stationed should arrange with the Commanding Officer to speak with them and to counsel with them and to encourage them that their interest will be maintained. If the UMT has the 27 months of service now being discussed, then this becomes of greater import than ever. It is our duty to seek to reach these students wherever they may be, to encourage them that they hold fast to the engineering urge within them that they go forward.

I dedicate this, my first editorial, to the strength of our great engineering profession that we ourselves must work to maintain a continuous flow of new talent beginning at the high schools. This is our profession at work through individual and group action.

And what I have said for the engineers applies equally to the scientists who, I trust, will work independently through their organizations, or with the engineers where it is advantageous, to bring to the students in science the same urge to continue in their education that scientific achievement will be continuously maintained.

Everett S. Lee

WATTHOUR-METER CERTIFICATIO



F. H. Busch

The design, manufacture, and testing of watthour meters are carried out with such precision and reliability that it is now feasible to certify accuracy and performance

John C. Garrett

By F. H. BUSCH and J. C. GARRETT
Meter and Instrument Divisions
General Electric Company, West Lynn, Mass.

INCREASED productivity is the keynote to survival of the American way of life. To the electric utilities increased productivity is necessary to offset the increasing costs of materials and labor. The utilities can be justly proud of the fact that electricity costs have continued downward at a time when all other costs are rising.

The recently announced certification of the accuracy and performance of Type I-50 single-phase watthour meters (Fig. 1) provides opportunities to electric utilities for further reduction in their operating costs. Most electric utilities test all new meters before installing them for consumer billing. The meters are also subjected to varying degrees of mechanical and el trical inspection and tests as further assurance th they meet the utilities' established standards. C rently, the cost of such acceptance tests may ran from $.25 to $1.25 per meter, depending upon t practices of the particular utility.

The objective of certification is to provide met with such a high degree of accuracy and performan that there normally will be no need, *because of the met alone*, to make these incoming tests and inspectio Before any modern management accepts a new meth or system of operation, information and data must provided which will prove conclusively that satisfacto

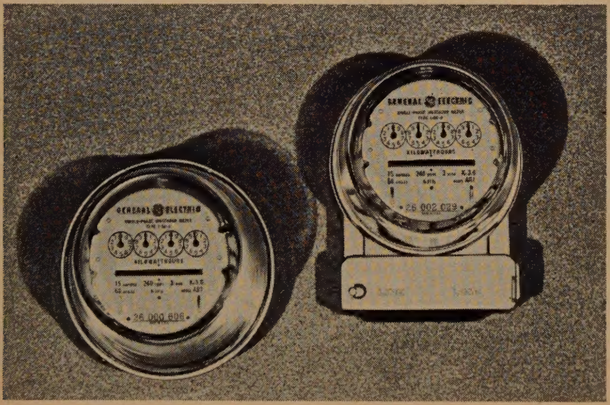


Fig. 1. Two new watthour meters. At right, bottom-connected Type I-50-A; at left, socket-connected Type I-50-S

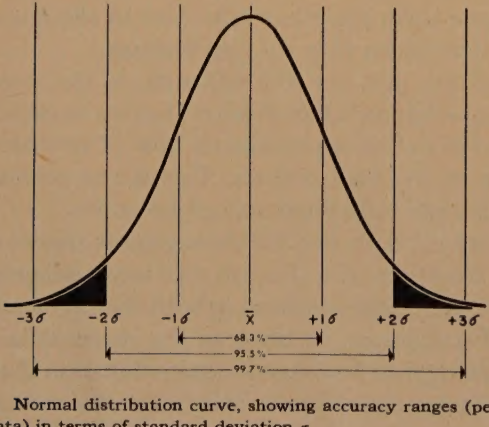


Fig. 2. Normal distribution curve, showing accuracy ranges (percent of total data) in terms of standard deviation σ

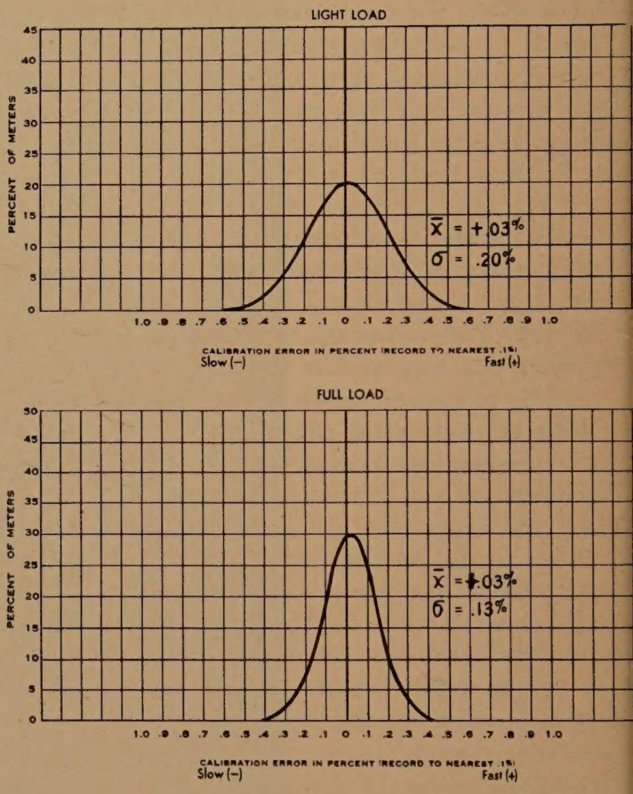


Fig. 3. Correlation of actual calibration data to normal distributio curve

---

This article is so paged that, without mutilating other articles, it ca readily removed for filing as a group of full-size consecutive pages.—Ed ɔerating results will be obtained. The certification ogram required that means of measuring the im-ɔrtant qualities of watthour meters be developed that ɔuld be used both by the factory and by the utility to hieve a higher level of accuracy and performance.

The measurement methods used in certifying I-50 eters will be of interest not only to persons interested watthour meters, but also to anyone interested in the ıality control of products that are made or used in rge quantities. The principles used are basic to the ience of statistical quality control. This article will nphasize the practical aspects of the certified meter ıality program rather than the theoretical.

ERTIFIED ACCURACY

The one and only reason for a watthour meter is to curately measure the total quantity of electricity sed by the load it is metering. From this measure-ent is determined the charge to be made for the energy sed. Since the watthour meter is truly "the cash gister of the electric utility," its accuracy as a measur-g device is of first importance.

Accuracy of Type I-50 meters as produced is certified y the utilization of a method new to watthour-meter ractice,(1) but old and accepted in the field of quality ɔntrol. First, the meter accuracies must agree with ıe reference kilowatt-hour standards. The average of l meter accuracies, called bar X ($\bar{X}$), as shipped is ithin ±0.1 percent of these standards. Shipping tests ɔow that changes in this average are extremely small.

Secondly, the distribution or dispersion of accuracy individual meters, about the average for the group, ust be small. This dispersion figure is the standard viation, called sigma (σ), and gives a very complete scription of normal data as shown in FIG. 2. The high gree of conformity of actual meter calibration data ith the "normal" law of probability (FIG. 3) proves at this means of evaluation is accurate. The values σ as certified at the factory are 0.15 percent or less ı full-load, and 0.20 percent or less on light-load curacies. This means that:

	Full Load	Light Load
68.3 percent or more were accurate to	±0.15%	±0.20%
95.5 percent or more were accurate to	±0.30%	±0.40%
99.7 percent or more were accurate to	±0.45%	±0.60%

hese accuracies are all measured relative to the aver-e $\bar{X}$ value. FIG. 4 shows the distribution curves of a pical month's production.

Here again, factory certification to these extremely ɔse limits would be of no value if there were large anges in the accuracy distribution during shipping. ıctory shipping tests prove these changes are minor IG. 5). Additional tests made by several electric ilities show a remarkable degree of conformity and further confirms that there has been small change in shipment and that their standards and test procedures also have a high order of accuracy (FIG. 6). These tests were made by utilities with bilateral test limits. Even where adjustment to unilateral limits is required, the uniformity of calibration combined with the linear adjustment features of the meter will permit savings in meter-shop testing.

To obtain the accuracy necessary for certification many improvements were undertaken simultaneously. The meters are first preadjusted before final calibration

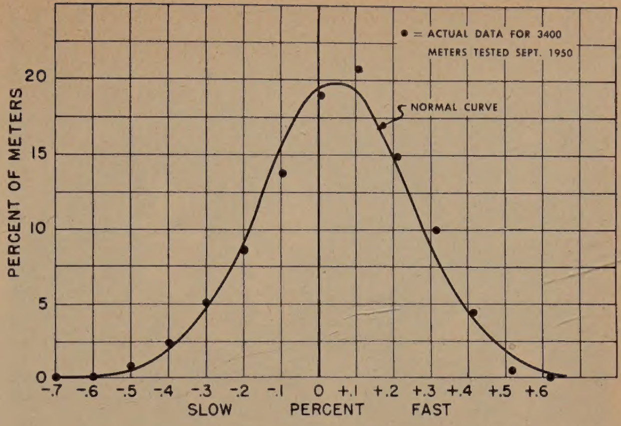


Fig. 4. Typical month's calibration curves

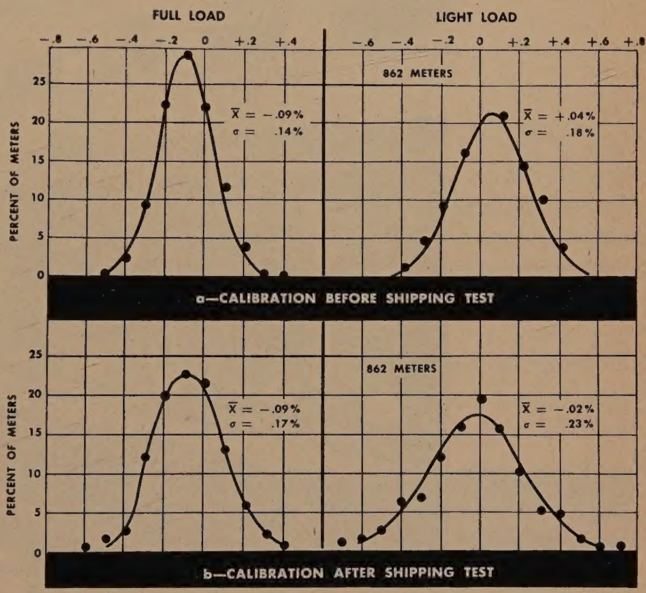


Fig. 5. Calibration curves for watthour meters before and after shipping test

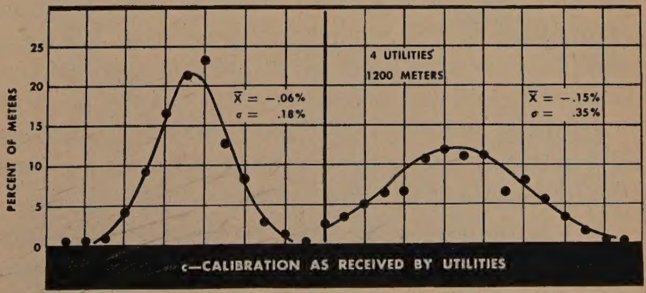


Fig. 6. Calibration curves for watthour meters as received and calibrated by utilities

---

(1) Numbered references are listed at the end of the article.

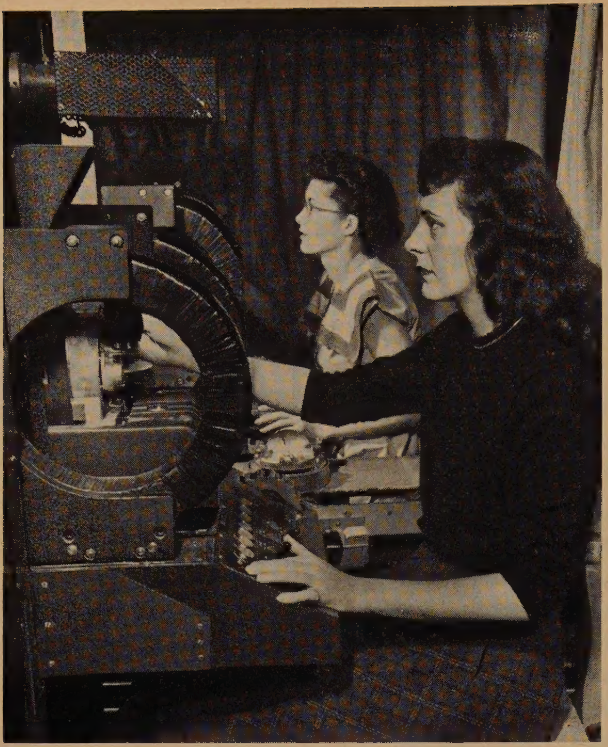


Fig. 7. Calibration preadjustment stations for full and light loads

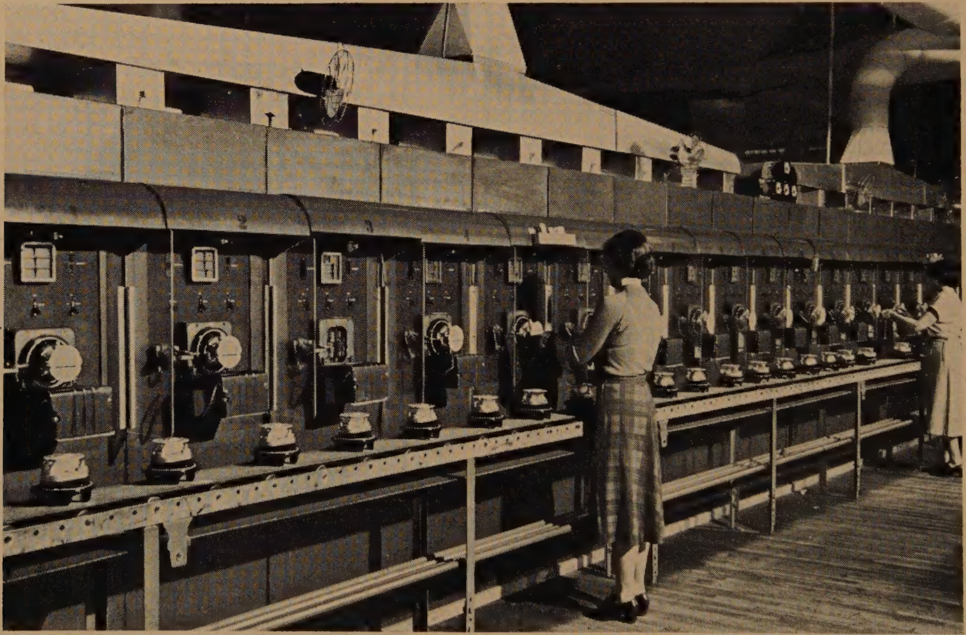


Fig. 8. Final adjustment and check stations. Twenty final test panels assure uniform accuracy. Each I-50 watthour meter is tested here for full, lag, and light loads. Each test panel itself is checked daily

(Fig. 7). Voltage regulators accurate to 0.1 percent were added to this equipment, permitting the meter calibration at this point to be within ±0.6 percent. With this calibration accuracy, the operators at the final adjust and check stations(2) are able to calibrate each and every meter to within the ±0.2 percent limits required on the final check equipment (Fig. 8).

In addition, over ten separate projects were undertaken to improve the repeatability, accuracy, and reliability of the final check stations. These included improved photoelectric light pickoff, improved reset gearing, improved switches to eliminate relays, a visors and guards to eliminate possible effects of dra and fans. Equipment was installed to more accurate control voltage and wave form, and to maintain loa

To assure that accuracy is maintained to the quired limits, a continuous sampling of meters selected at random from the conveyor belt after factory calibrations have been made.(3) The meters tested by a laboratory technician on separate equi ment maintained for this purpose (Fig. 9). The la oratory engineer and the factory quality control en neer review daily a distribution plot of each da results. In addition, a complete weekly review a analysis is made. If the results do not indicate sat factory quality, corrective action is initiated. Such c rective action may be recalibration of test equipme maintenance or repair of equipment, or warnings to t operators to exercise greater care in final calibration.

CERTIFIED PERFORMANCE

The mechanical and electrical qualities of a meter equally important to the electric utility. However, different measure for performance is necessary than used for accuracy. Accuracy or meter error is a matt of degree. It is normally measured in multiples of percent from true accuracy. Performance, on the ot hand, is a "go" or "no go" measure. The meter eit passes or does not pass the standards set up. Acco ingly, it is measured as a straight percentage rat than using the distribution-curve method.

The I-50 is certified that quality is such that o 99.9 percent of the meters are free from defects t might cause improper registration or operation. T means that less than *one* out of 1000 meters may h some such defect. Even then, records show this def be of a temporary nature in a high percentage of the es. As long as there is a human element present, fection cannot be realized. The high order of permance being certified is difficult of achievement and uires constant surveillance to assure that it is mainned.

t is probably quite trite to say that "Quality is built o a product—not inspected into it." From a practical

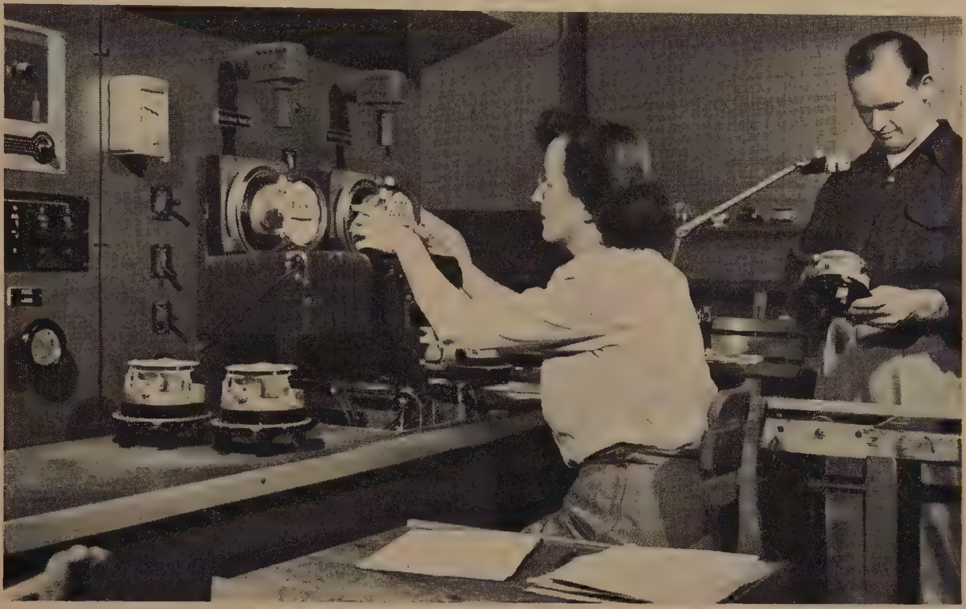


Fig. 9. Laboratory accuracy check station for test of meters selected at random after all factory calibrations have been made

wpoint, inspection methods, particularly those reiring human perception and judgment, are only able reduce the percentage of defective units which may st in a group of a product, but never to completely minate them. If the quality level of the product is before inspection, it may be greatly improved by inspection. If the initial quality level is higher, the ality after inspection will also be better. Of course, if s thinking is carried on it leads to the conclusion that eries of three or four repetitive inspection operations uld result in an infinitesimally small chance of a ect being overlooked. Unfortunately, such inspection ocedure is not as effective as such reasoning would licate, since the law of diminishing returns seems to ply. This seems to be particularly true of a product complex as a watthour meter.

Recognizing these facts, the manufacturer's approach the problem of over-all performance quality of wattur meters is not one of adding more and more inction of the final product, but rather of eliminating ficulties before they happen. This may be achieved design of product, design of tools or equipment, imved processing methods, or by specific inspection for particular defect at the source of the hazard. The nufacturer's objective is to realize such an excellent r-all outgoing quality level that the user will iously consider whether further inspection and tests r any possible net improvements. This is admittedly a very high objective and one that has been difficult to attain.

Though the I-50 meter was being produced with a quality level superior to any previously realized in the watthour-meter industry, consideration of certification required that further measures be taken to meet the high objectives set as the goal. Engineering, inspection, laboratory, and manufacturing organizations worked together over a period of nine months before the objectives were realized. In addition to this, the productivity of this co-operative effort has resulted in many ideas for even further improvement. Such a situation is very healthy, since better quality will be realized only by an organization which is continually challenging itself to do better.

For certified performance, cleanliness of parts and work space is of paramount importance. Covered assemblies on conveyors (Fig. 10), continuous vacuum clean-

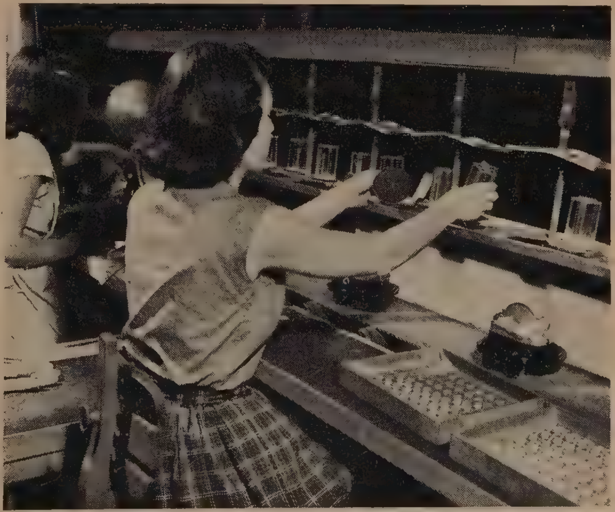


Fig. 10. Covered assemblies of magnetic-suspension-type moving elements on conveyors is an example of care exercised in manufacturing

ing of conveyors and work areas, and cleaning operations at all stages of manufacture were instituted.

New molding methods for the polyethylene insulated potential coil and butyl-molded current coil to eliminate flash removal results in the ultimate in cleanliness of the electromagnet. The absence of a multitude of insulating pieces, as are used in other meters, is as important to certified performance as any other one feature.

Where permanent magnets are used for controlling accuracy, as they are in a watthour meter, the hazard of magnetic dirt creates a particularly severe problem. To reduce this hazard, a procedure of manufacture was adopted whereby the magnets were not magnetized until the major portion of the meter assembly was completed. This reduced the time and operations which exposed the meter to the hazard. In addition, new methods of blast cleaning of the frames and bases are being instituted to reduce the chance of their carrying dirt or lint particles into the assembly.

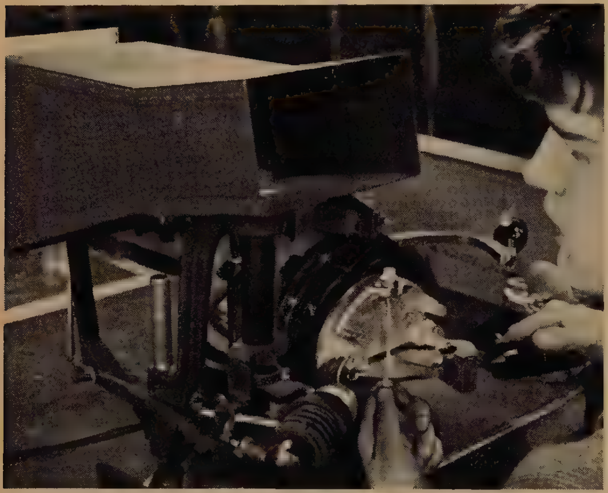


Fig. 11. Shadowgraph fixture for adjusting disk position. Rotating element is precisely set in air gap. Projection method shows relative position of suspended floating disk and magnets. When set, disk is permanently positioned by stable suspension magnets

Improved shadowgraph fixtures for adjusting disk positions (FIG. 11) checking disk runout, and setting register mesh gives greater uniformity in settings and has practically eliminated rejections for those causes.

In addition to the standard high-potential tests given the electrical conductors, voltage surge tests are given the potential coils.

Inspection procedures were reviewed and revised on the basis that there should be some form of checking upon the quality of inspection of each inspector and that the initial inspection be as near the possible source of difficulty as practical. To provide control of the quality as the meters are being built, a complete quality control indicator system was installed on the conveyor (FIG. 12). Visual indicators are installed in the general foreman's office as well as at the end of the conveyor. These indicators give immediate calculation of the percentage defective at ten different points of inspection.

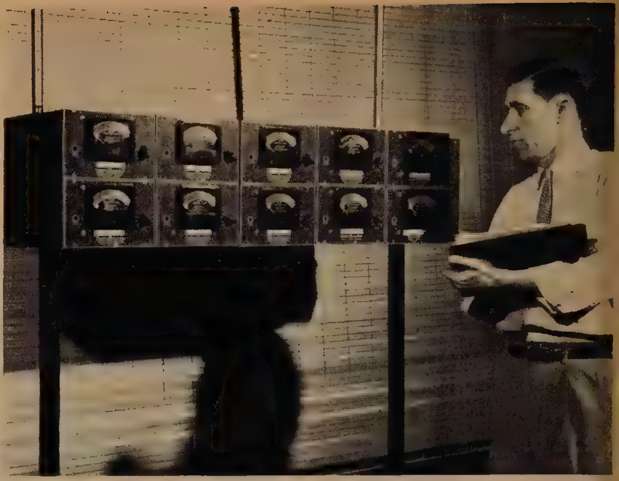


Fig. 12. Quality control indicators that are associated with the final assembly conveyor

Immediate correction can then be initiated, thereb eliminating defects before they are produced.

During the manufacture, each watthour meter tested and inspected at every stage of constructio This begins with acceptance tests on the various materials to be used. Subassemblies, such as the shaft an guide bushings (FIG. 13) are given microscopic an mechanical inspection to determine that the parts ar mechanically perfect. Altogether eighteen separat tests and over 350 items of inspection are performed t produce each meter.

To determine the average outgoing quality, sampling of the product equal in quantity to tha tested for accuracy is taken after all production operations are completed and the meter is ready to be boxe These samples are subjected to a series of tests an inspections that are designed to detect any defec

Fig. 13. Microscopic inspection of shafts and guide bearings. Magnetic suspension eliminates all vertical bearing pressures; and side thrust against graphite guide bushings, which are being inspected here, is 2000 times less than total bearing pressure of conventional meters

ich would adversely affect performance. Specially ained laboratory technicians are charged with the sponsibility of making the following tests:

(1). High-potential test

(2). Calibration test

(3). Complete visual examination for:

  (a). Cleanliness

  (b). Proper assembly

  (c). Proper adjustments

Trend charts are maintained of the performance per- ntage. If any tendency is noted where this may go yond the control point, the necessary corrective tion is taken.

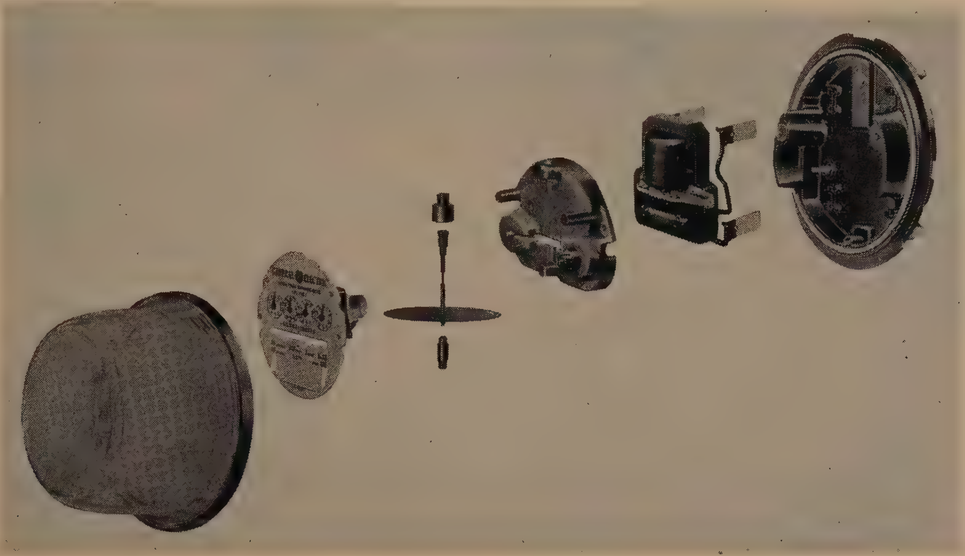


Fig. 14. View of disassembled I-50 watthour meter, showing structure of principal parts

SIGN FOR CERTIFICATION

While the proper execution of a program for "Certi- d Accuracy and Performance" rests primarily upon e manufacturing and inspection organization, they ust be provided with a design for the product which rmits the practical attainment of such a goal.

The development and design of the I-50 watthour eter(4) had consideration of high quality manufacture a prerequisite. It will be noted that many of the fine tures of the meter provide outstanding user advan- ges combined with straightforward, efficient, and iable manufacturing techniques.

The design is simple (FIG. 14), reducing the number parts and assembly operations to be performed. The lusion of the braking magnets within the die-cast me gives a higher degree of calibration stability and minates assembly operations which would otherwise roduce hazards of improper performance. The single- ce plastic base, likewise, gives greater corrosion re- tance and eliminates assembly operations and zard of dirt and lint from gaskets and handling. Rivets are used in the assembly wherever practicable, since they reduce the chance of chips and dirt from the tapped holes, screw threads, and screwdriver slots. In addition, riveting reduces the hazard of improperly tightened screws, since automatic fixtures and presses largely eliminate dependence upon the human element.

CONCLUSION

Certification of the accuracy and performance of the Type I-50 watthour meter has been undertaken in order to provide a new opportunity for the electric utility to reduce its operating expense. This development invites consideration as to the necessity for testing and inspection of new meters before placing them in service or at least for reducing these tests to a minimum where regulatory requirements make such a test record mandatory.

An unprecedented quality level is being realized in producing watthour meters through the intelligent use of modern quality control techniques combined with the most modern design of watthour meter now in existence. The full advantage of this high quality cannot be realized until the benefits are understood and evaluated. The "Certificate of Accuracy and Performance" brings this subject to the utilities' attention for consideration, study, and as an opportunity to take advantage of this advancement in the art of metering.

REFERENCES

(1)"Two Numerical Indexes Evaluate Masses of Meter Data," by F. H. Busch, *Electrical World*, vol. 134, no. 25, Dec. 18, 1950, p. 84.

(2)"Improvements in Modern Meter Testing Technique," by Edward E. Lynch and M. A. Princi, *Paper No. 42-71, AIEE, Trans.*, 1942, p. 218.

(3)"Quality Control in Production Testing of Single-phase Watthour Meters," by T. M. Wallis, GENERAL ELECTRIC REVIEW, vol. 50, April 1947, p. 38.

(4)"A New Watthour Meter," by I. F. Kinnard, *Electrical Engineering*, vol. 67, July 1948, p. 627.

When you specify Mallory Capacitors for television receivers or other equipment where heat is a problem, you can be sure they will stand the test. Mallory FP Capacitors are designed to give long, trouble-free performance at 85°C. —naturally they give even longer service at normal temperatures. In addition, Mallory FP Capacitors are famous for their long shelf life. Write for your copy of the FP Capacitor Engineering Data Folder.

Mallory Precision Production

pays off again in "shelf-life" demonstration

When a large radio and television manufacturer found it necessary to fall back on a supply of two-year-old capacitors, they found that every one of the Mallory Capacitors was ready for immediate use — without re-working of any kind. Because of the scrupulously careful manufacturing methods pioneered by Mallory, they were completely free of corrosion.

Mallory Capacitors have consistently set new high standards of dependability which far exceed normal specifications.

That's service beyond expectations!

P.R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

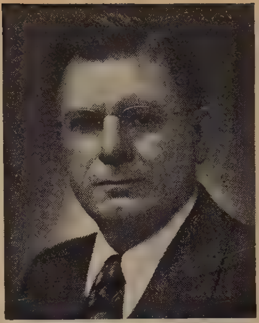
Electromechanical Products
Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

Metallurgical Products
Contacts *Special Metals*
Welding Materials

AS-TURBINE POWER PLANT COMPLETES YEAR AND A HALF OF OPERATION

Simple-cycle plant of Oklahoma Gas & Electric Company, first in commercial power-station service, gives a good performance record



B G Hatch

By B. G. HATCH

Gas Turbine Sales Division, General Electric Company

HE 3500-kw combustion gas-turbine power plant in the Belle Isle Station of the Oklahoma Gas & ctric Company has very successfully completed over 00 hr of firing operation and has generated in excess 46 million kw-hr since its installation in July 1949. ngineering details(1) of this power plant and the gineering analysis(2) leading to its purchase and inllation have been presented in the technical press and ore the National Societies. This article concerns the ration and performance of the plant. Briefly, the le Isle Station of the Oklahoma Gas & Electric Comny had steam-turbine shaft capability of 56,000 kw, was limited in its output by a boiler capability of 000 kw. The steam turbines were operating on the regenerative cycle, heating their own feed water by raction. With the rapid growth in load, the Oklama Gas & Electric analysis indicated the greatest tem benefit for both increased power output and imved operation at the lowest cost and in the shortest e could be obtained by the installation of a 3500-kw ple-cycle gas-turbine power plant, utilizing the ste heat from the exhaust to heat a portion of the ler feed water in the steam station. A portion of the racted steam formerly used for boiler feed-water ting is thus permitted to pass through the condens- stages of the steam turbines, thus obtaining more kilowatt capacity with the original boilers. Under favorable circumstances there is a plant pickup in the order of 3000 kw in addition to 4000 kw of new power added by the gas turbine.(2)

This, the first commercial combustion gas turbine in America, has now completed 18 months of successful base-load operation in a major generating station on the Oklahoma Gas & Electric System, with outstanding success. It is designed to burn natural gas of approximately 1180 Btu per cu ft, which is supplied to the fuel regulator at a pressure of 150 psi gage and, in addition to the secondary heat recovery apparatus, was equipped by the operating company with an intake air precooler to permit increased capacity from the gas turbine during periods of high outdoor ambient temperature. Make-up water for this company's cooling pond is obtained from deep wells at 65 F so that some measure of cooling can be obtained in cooling the intake air at any time the outside air exceeds standard 80 F.

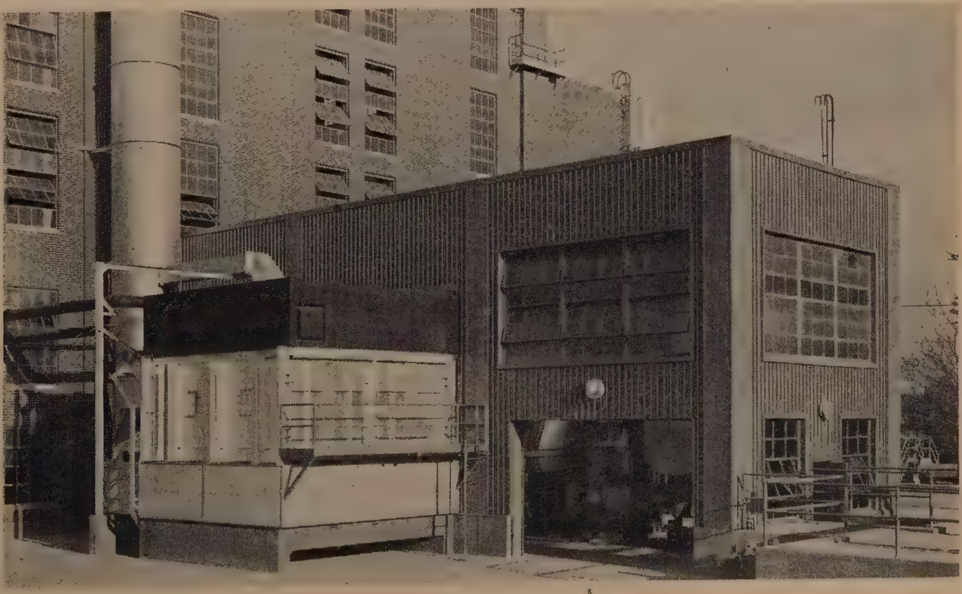
EARLY OPERATING HISTORY

Because it was the first gas turbine of its type, both manufacturer and operator were much interested in observing its performance. A mutual arrangement was

---

1) Numbered references are listed at the end of the article.

This article is so paged that, without mutilating other articles, it can be readily removed for filing as a group of full-size consecutive pages.—EDITOR



as turbine power plant installaion at Belle Isle Station of the Oklahoma Gas & Electric Comany as an annex to generating tation. This view shows exhaust eat recuperator worked out during the early operation to permit overnight inspection of the combustion chamber system, after a 14-hr daily operating period through system peak. Since these nightly inspections showed nothing unusual, the inspection periods were subsequently increased to week-end inspections, and still later to monthly inspections; and within the first few months of operation there were three continuous operating periods without shutdown of approximately 690 to 732 hr. The only unusual circumstance during this time was that oil vapor from the lubricating oil system vent was carried by prevailing winds into the air intake, resulting in some fouling of the compressor blades, with loss in capacity of 200 to 300 kw. The oil vent piping has been changed to prevent a recurrence of this condition.

Following the cleaning of the compressor and subsequent months of operation, and in accordance with the operating company's standard practice on all new rotating equipment, the gas turbine was completely disassembled for detailed inspection by the operator and the manufacturer at the end of the first six months, and all parts were found to be in excellent condition.

This occasion was taken by the manufacturer to replace the original first-stage nozzle spacer blocks with an improved design, as the result of experience with another test unit. These space blocks in the Oklahoma Gas & Electric machine were in good condition and would not have required replacement, except for the design improvement.

The power plant was reassembled with all of th original parts and successfully operated with no un usual incidents until the end of the first 13-month per od when it was only partially inspected by removin top-half covers, but without removing the rotors fro their bearings. Again the machine was found in exce lent condition and was reassembled and placed in ope ation with no replacement of maintenance parts.

During this period the early operating experience wa presented in an article(3) which included a chart pre pared by the operating company showing hours c availability, with the outages for planned inspectio and maintenance. Despite the frequent inspections pre viously referred to, this new prime mover showed a availability of 84 percent during this early perioc This article(3) also gave the operating company's in stallation costs for all purposes, and some basic ope ating data through the first six months.

LATER OPERATION

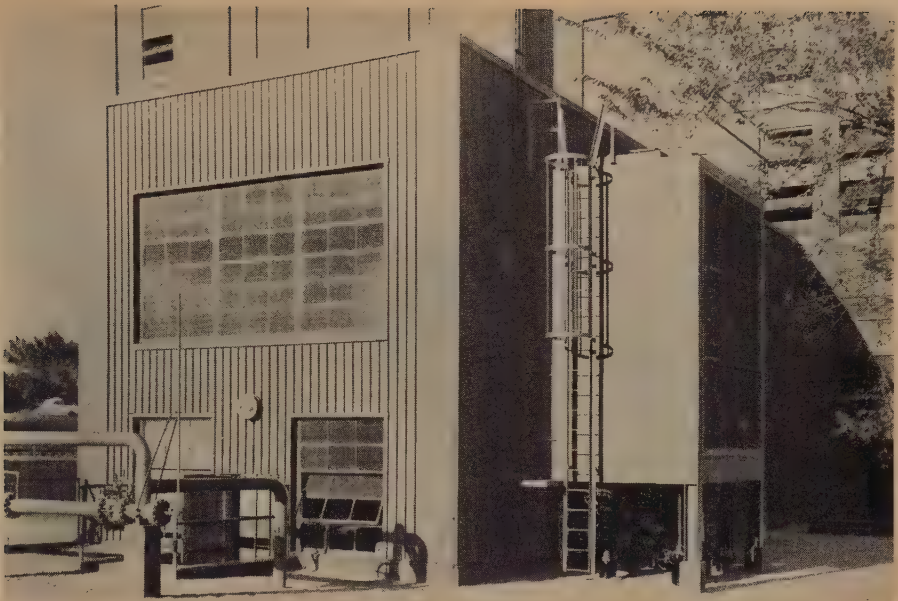
Following the very excellent appearance of the ma chine at the 13-month-period inspection, and with th approval of the manufacturer, the combustion-chambe inspection periods were lengthened to 1000 hr, and th operating temperatures were raised slightly to obtai greater average output.

The gas-turbine power plant is rated on the basis c standard conditions of 80 F ambient and 1000 ft ele vation. A characteristic of the gas turbine results i

TABLE I: PERFORMANCE DATA

Period covered, July 29, 1949 to December 27, 1950; total operating hours, 10,313.
Equipment ratings: 130,000-kw steam turbine; 120,000-kw steam turbine; 13,500-kw gas turbine.

Station Operation:	
Average load on station, kw	40,915
Average load on gas turbine, kw	4231
Average load pickup through gas turbine exhaust recover, kw	2400
Average load credited to the gas-turbine fuel, kw	6631
Unit capacity factor, station, percent	86.
Unit capacity factor, gas turbine, percent	120.9
Average fuel to gas turbine (natural gas) in million Btu/hr	86.
Average heat pickup from gas-turbine exhaust to feedwater, million Btu/hr	39.2
Average heat rate from gas-turbine exhaust recovery, Btu/kw-hr, (HHV)	16,380
Corresponding thermal efficiency (HHV)	20.2
Average heat rate from gas-turbine fuel, Btu/kw-hr (HHV). Total station increment	12,966
Corresponding thermal efficiency (HHV)	26.3
Average heat rate regenerative feed-heating portion of station, Btu/kw-hr (HHV)	15,579
Corresponding thermal efficiency (HHV)	21.9
Average heat rate, total station, Btu/kw-hr (HHV)	15,229
Corresponding thermal efficiency (HHV)	22.41
Gas Turbine Data:	
Average compressor air-inlet temperature, deg. F	62.1
Average turbine-inlet temperature, deg F	1342
Average exhaust temperature, deg. F	799
Max load (56 deg F compressor inlet-air temperature) kw	5000
Gross generation, gas-turbine generator, kw-hr	43,631,000
Gross generation, gas turbine-steam turbine combination	683,820,000
Steam Turbine Data:	
Average steam pressure, psig	402
Average steam temperature, deg F	728
Average condenser, back pressure, in. Hg	2.0
Unit fuel cost, gas turbine-steam turbine combination, mills per kw-hr	1.1
Unit fuel cost, total station output, mills per kw-hr	1.3



Exterior view of gas turbine power plant building, showing air intake and precooler housing

omewhat reduced load with higher ambient temperaures. This was partially overcome by the air pre-cools referred to previously. On the other hand, with reuced ambient temperatures, the gas turbine will carry ad in excess of rating with improved heat rate. Very rly in the operating history, the maximum load with w ambient temperature was carried to 5000-kw output. Anticipating this overload capacity, the 3500-kw s turbine was originally provided with a 4000-kw 8-pf 5000-kva generator. With the slight increase in perating temperatures, base loads consistently in exss of rating have resulted in an over-all average output of better than 4200 kw, with a maximum of 5000 w which is a mechanical limitation suggested by the anufacturer.

During these 11,000 hr of operation the power plant as been forced off the line on only two occasions. The st was from the failure of a defective lubricating oil ump impeller. The supervisory control of the gas turne automatically started the emergency lubricating l pump and, with loss in pressure, automatically shut own the machine. The operation of the emergency luricating oil pump resulted in no damage to the bearings shaft. A new pump impeller was shipped by air express and the machine was back in operation in 30 hr. he second forced shutdown resulted from a burnedut flame detector and again the supervisory control hich is of the "fail-safe" type took the machine off the ne. A spare detector was installed and the unit was ack on the line in four hours.

The periodic combustion-chamber inspections connued to be so favorable that the operating company as suggested extending the inspection periods to 1500 , and to place the entire power plant on the same ree-year teardown basis that is followed with their eam turbines.

The operating company has on numerous occasions pressed complete satisfaction with the results obined in the operation of this unit.(3)(4)

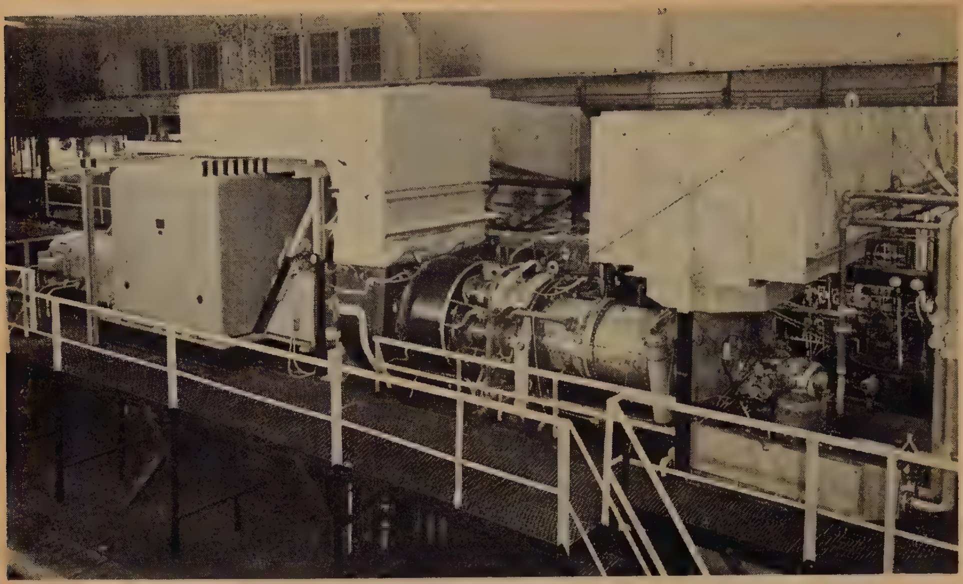
PERFORMANCE RESULTS

To many, an incremental prime-mover of only 3500-kw rating would seem too small for a large public utility. It is most interesting to note that not only has this gas turbine justified its purchase by increasing the output of the original steam plant by some 3000 kw, resulting in a total increment under favorable conditions of 7000 kw; but it has also at the same time improved the operating economy of the steam station.

Based on a total design input of 80,400,000 Btu per hr, the guaranteed heat rate is slightly under 23,000 Btu per kw-hr. Because of the high average load of 120 percent of rating, and the resultant better economy, the average weekly heat input is approximately 20,000 Btu per kw-hr based on the gas-turbine input alone, and with no credit for either secondary heat recovery or incremental pickup in the Belle Isle Station.

Operating economies have been recently released by the operating company(5) for the first 7600 hr of operation. These data have been brought up-to-date as of Dec. 27, 1950, for over 10,000 firing hours and provide the basis for Table I. A careful study of the data shown in Table I will bring out many interesting points which may be unique to this installation, but which illustrate the flexibility of gas-turbine power plant application. For instance, by the addition of a 3500-kw nameplate rating, which is only seven percent of the station's former 51,000-kw capability, the average station kilowatt load has been increased by 16 percent. This is due in part to the average 120 percent output obtained from the gas turbine together with the station pickup which was made possible by the boiler-feed-water heating from the gas-turbine exhaust.

It is especially interesting to note that with the addition of the gas turbine which has a basic heat rate of approximately 23,000 Btu per kw-hr, the average station operating economy of approximately 15,600 Btu per kw-hr was actually improved. This paradox comes from the fact that the total heat imput which would



The 3500-kw gas-turbine-generator set up for test at factory

ordinarily be charged to the gas turbine alone results in an average station pickup of 2400 kw which can be credited to the gas turbine fuel, resulting in a heat rate for the total station increment in the order of 13,000 Btu per kw-hr.

COSTS

The total installed costs of the gas turbine power plant including secondary heat recovery apparatus and including the necessary changes to the steam station's boiler-feed-water heating system, and the electrical additions to the steam station have been published by the Oklahoma Gas & Electric Company(3) as $730,000. Taking into account the average gas turbine increment shown in Table I, the incremental capital cost per kilowatt is only about $112. On a peak load basis of 7000 kw increment under favorable conditions, the capital cost is very close to $100 per kilowatt.

If the secondary heat-recovery equipment, together with reduction in required duct work, omission of piping and control for boiler-feed-water heating, and similar excess costs are deducted from the total cost of the Belle Isle installation, the installed cost of the gas-turbine power plant and its building alone is estimated at about $650,000 or only $160 per kilowatt based on a conservative average of 4000-kw output. In view of the increases in both labor and installation since the purchase of this gas turbine, the foregoing figures perhaps could not be repeated; but with strict economy in construction and design, they could be closely approximated.

This gives point to the economies which can be effected in the installation of a gas turbine, since the minimum of building, foundations, and crane handling equipment are required. In general, no basements are required, and except for the excavations necessary to obtain proper sub-soil footings for the foundation and a pit for the lubricating oil system, with possibly a trench or a tunnel for cooling water pipes and generator leads, the gas turbine station can be constructed wholly on a mat above the grade level.

Since this was an addition to an existing generating station, no additional operating personnel were needed. Following a manual start from the gas-turbine control board, the unit is left to operate by itself, subject to the automatic protection features of the starting and supervisory control panel. For an independent station it would probably be desirable to provide a full-time operator and assistant on each shift. The assistant could, of course, have other assigned duties not properly chargeable to the gas turbine. The present controls for the gas turbine can, in fact, very easily be applied to full automatic start controlled from a remote station when using natural gas for fuel; and, owing to the automatic supervisory features, the gas turbine may be installed in a nonattended station when conditions warrant.

Other than labor for inspection, the maintenance cost of the gas turbine has been especially low.(5) This has been estimated by the operating company to be approximately $1 per kilowatt-year and is estimated to be approximately 20 percent less than that for the total station. The high over-all economy of the gas-turbine power plant together with its incremental pickup has resulted in unit costs of approximately 1.6 mills per kw-hr compared to the total steam station operation of 1.88 mills per kw-hr.

SUBSEQUENT INSTALLATIONS

In addition to the Oklahoma Gas & Electric unit described, a duplicate prototype of this design was extensively factory-tested, installed in a 4500-traction horsepower gas-turbine-electric locomotive, and has been operated approximately 5600 hr and 85,000 mi in revenue freight service on the lines of the Union Pacific Railroad. The operation of this unit has been so successful that the Union Pacific Railroad has recently announced placing orders for 10 duplicate, but somewhat improved, locomotives.

A unit duplicate of the Oklahoma Gas & Electric power plant, except burning oil and without secondary heat recovery, has been installed in the Farmingdale tation of the Central Maine Power Company and vent into commercial operation in August 1950. This nit replaces a 2000-kw low-pressure low-temperature team turbine and its boiler of the vintage of about 914, at ½ the fuel rate. Since the Farmingdale Station s a peak-load and standby station for the system, and o be operated mainly in times of peak load or adverse vater conditions, this unit as yet has accumulated nlý a few hundred hours operating time. One of its hief advantages is its ability to be started from cold nd its availability for service in four minutes when its ervice is required. It is then operated at or near its ated base load.

ONCLUSIONS

In the words of J. W. Blake, Assistant Superintendent f Generation in his recent paper before the ASME(5):

> "The performance of this unit in utility service definitely shows that a new type of prime mover is here. It compares favorably with other types in all respects. We can all be grateful to a manufacturer whose technical and engineering talent, together with design ingenuity, has advanced a much publicized machine to an actual installation."

From the beginning the Oklahoma Gas & Electric ompany has shown a spirit of most enthusiastic co-peration and interest in this first installation of gas urbine power plant. The fundamental theory of a uccessful gas turbine has long been considered by the ngineering profession as an ideal power plant. Limiations of metals to withstand the direct firing involved, ogether with only recent developments of components f sufficiently high efficiency, and the very high deelopment expense of investigating the innumerable onditions which must be co-ordinated in the over-all ower plant design have for many years delayed producion of a commercially practical gas turbine. The uccess of this first commercial installation in America s therefore most gratifying to all who have been inolved, and has been the subject of intense interest on the part of literally thousands of engineers who have been the guests of the Oklahoma Company in the inspection of this installation.

We wish to particularly thank Otis Howard, C. C. Willis, J. W. Blake, G. D. Conley, and numerous of their associates in the Oklahoma Gas & Electric Company who have given so willingly of their time in making possible the data on operating experience which has been briefly reviewed in this article.

REFERENCES

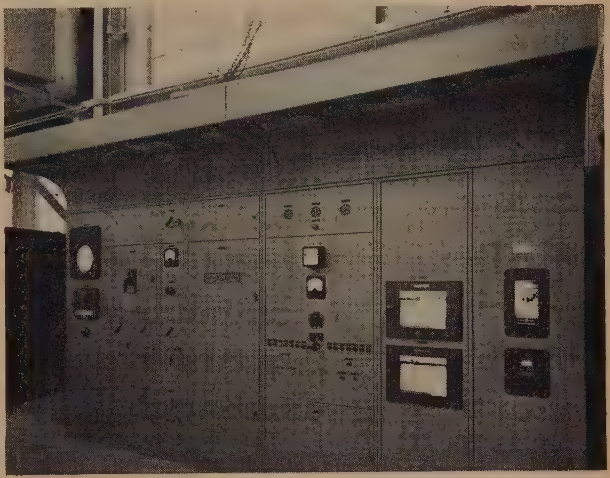
(1)"Design Features of a 4800-hp Locomotive Gas-Turbine Power Plant," by Alan Howard, *Mechanical Engineering*, vol. 70, April 1948, pp. 301-306.

(2)"3500-kw Gas Turbine Raises Station Capacity by 6000 kw" by J. W. Blake and R. W. Tumy, *Power*, vol. 92, September, 1948, pp. 518-525.

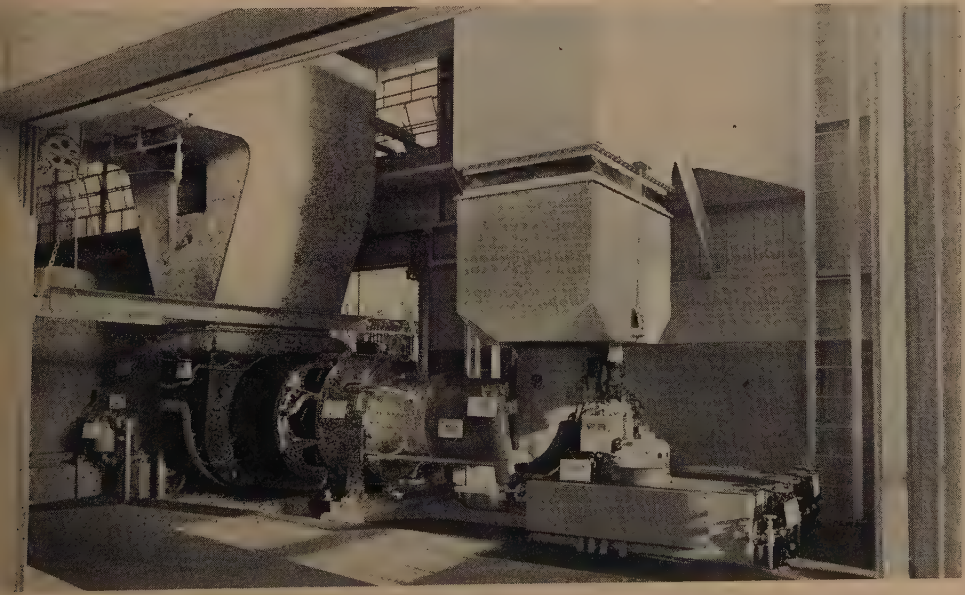
(3)"Huey Gas Turbine Ticks Off 3400 Hours," by J. W. Blake and R. W. Tumy, *Power*, vol. 94, February 1950, pp. 96-101.

(4)"Huey Gas Turbine Establishes Excellent Operating Record," by J. W. Blake, *Electric Light and Power*, vol. 28, August 1950, pp. 62-70.

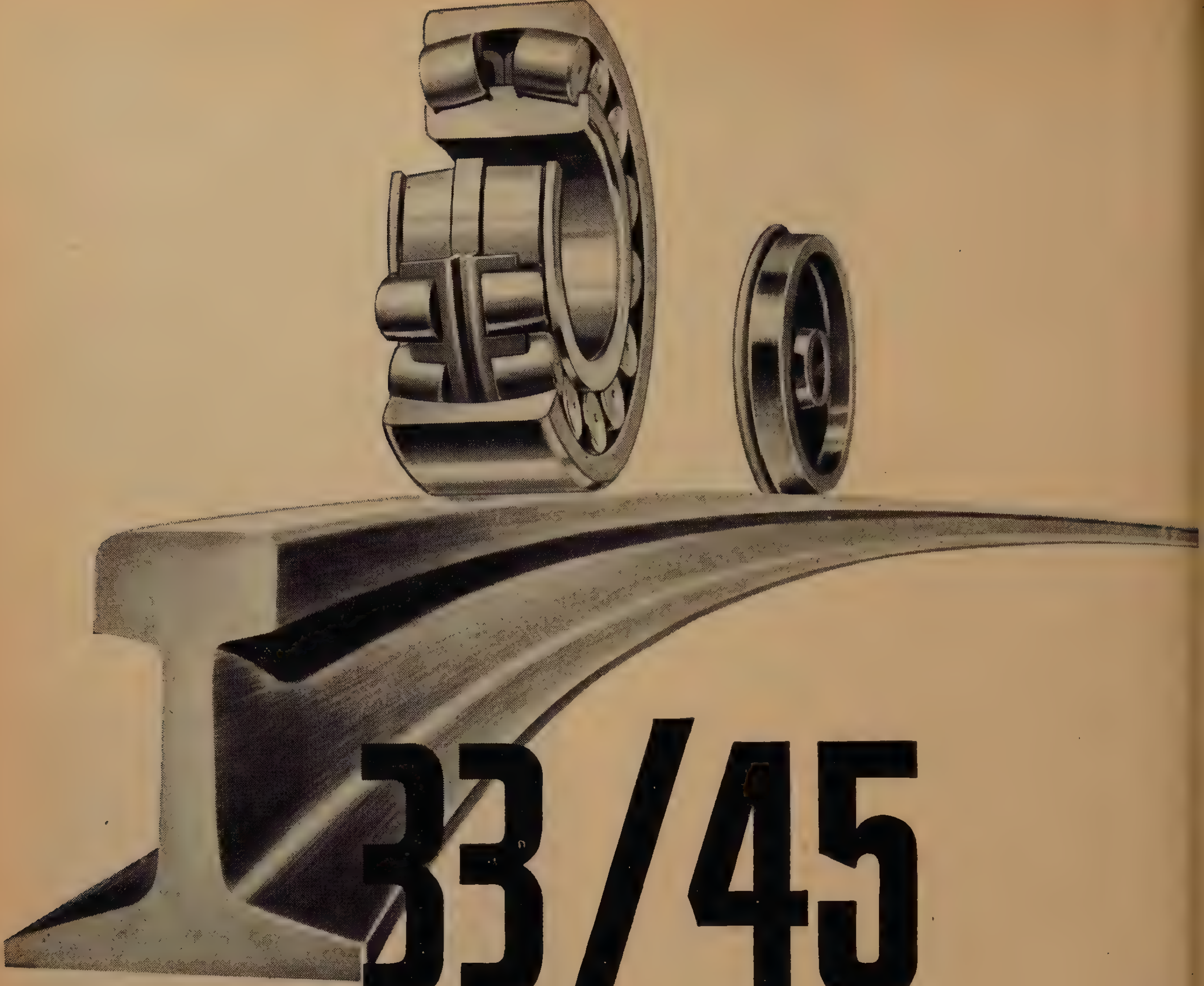
(5)"Combination Gas Turbine-Steam Turbine Unit, Performance of Installation Buring Natural Gas at Belle Isle Station," by J. W. Blake, presented at the annual meeting of the American Society of Mechanical Engineers, New York, November 26–December 1, 1950.



Control center for the 3500-kw installation of the gas-turbine plant at the Belle Isle power station



The power plant unit installed at Oklahoma Gas & Electric Company station. The placards were used during an inspection tour of this pioneer installation of a gas turbine for commercial power supply



33/45

YES, 33 OUT OF 45
MAJOR* CLASS I RAILROADS
USE SKF JOURNAL BOXES

This reliance on **SKF** by an industry whose standards for reliability are so high is typical of **SKF**'s acceptance by *all* industry. 7166

8 REASONS
WHY SKF
IS PREFERRED
BY ALL INDUSTRY

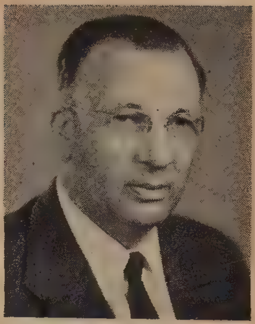
integrity
craftsmanship
metallurgy
tolerance control
surface finish
product uniformity
engineering service
field service

SKF
BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PENNA.
-*manufacturers of* SKF *and* HESS-BRIGHT *Bearings.*

*Annual Revenue Of $25,000,000 Or More

RÉSUMÉ OF THE GAS TURBINE-ELECTRIC LOCOMOTIVE



a H Morey

Results and evaluation of the newest form of rail motive power after a year and a half of test in freight service. Ten units have been ordered for regular commercial use

By A. H. MOREY

Locomotive Engineering Division
General Electric Company, Erie, Pa.

THE DEVELOPMENT of gas turbine power plants for aircraft propulsion during World War paved the way for a forward step in the evolution motive power for American railroads. This type of ime mover, with its low specific weight and space quirements, was particularly interesting to locomove designers. While the efficiency of the simple gas rbine plant was relatively low, it offered good possilities of burning low-grade, low-cost fuel.

Exploratory studies were started in 1942. By 1945, e development of gas turbine power plants and the ogress of the locomotive studies indicated that such locomotive could be built. Moreover, it apparently fered the possibility of lowering operating costs and abling railroads to use cheaper and less critical fuels.

The engineers in charge of these studies fully appreated the magnitude of the task before them. During 36-1941 a developmental steam turbine locomotive d been built and tested in railroad service. It demonrated two fundamental facts: first, the development a new type of motive power is a long-range project; cond, it must be pointed at a mass market, and very reful consideration must be given to future costs. Moreover, such a development can succeed only if it makes a definite contribution to the industry.

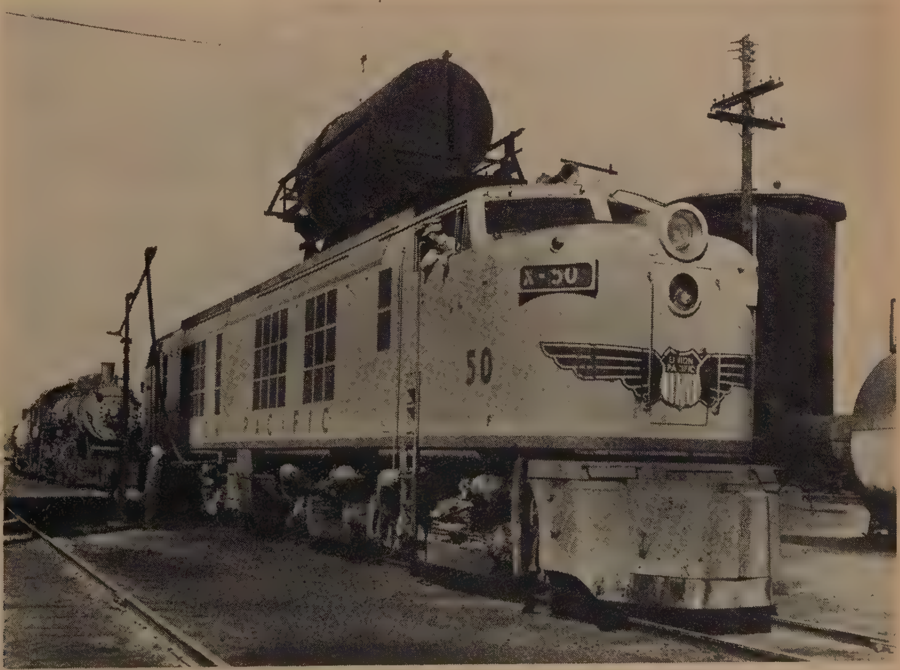
Motive power studies showed that approximately 90 percent of the locomotives in road service in the United States are freight locomotives, and that this percentage is increasing. Also, approximately 90 percent of these freight locomotives are in the 4500–6000-hp range. The mass market is, therefore, clearly defined. Forecasts of liquid fuel available and trends in refining indicated the desirability of using low-grade fuels, especially if coal could ultimately be considered as a possible fuel. The use of these fuels, together with the potential reduction in maintenance costs offered by the gas turbine power plant, would do much to reduce railroad operating problems.

For many years the trend in both steam and electric locomotives has been toward higher horsepower per axle. Steam is using approximately 800 hp, and electric trolley locomotives run as high as 1250 hp per axle. Current practice in freight service on diesel-electrics, however, is approximately 350 rail horsepower per axle. Application practice for these locomotives has been built up on this basis, especially for grade operation.

The design chosen for the gas turbine-electric locomotive was such that, with conventional ratings, the

---

This article is so paged that, without mutilating other articles, it can be dily removed for filing as a group of full-size consecutive pages.—EDITOR



eling the 4500-hp gas turbine-elec-
: locomotive

rail horsepower per axle would be approximately 450. As the ambient temperature and elevation decrease, the available capacity of the power plant increases, permitting full use of the generator capacity under these conditions. This results in a maximum sustained rail horsepower of 540 per axle.

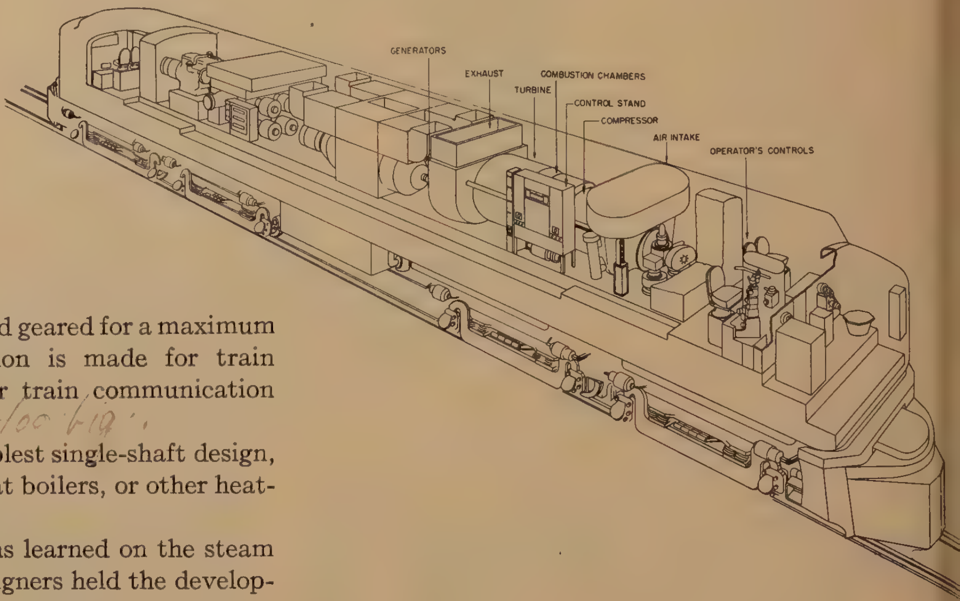
The locomotive designed to produce these characteristics is a single-unit 8-axle 8-motor double-end machine, weighing approximately 500,000 lb. It is built exclusively for freight service, and geared for a maximum speed of 69 mph. No provision is made for train heating, high-speed braking, or train communication signals. Power units too big.

The power plant is of the simplest single-shaft design, using no regenerators, waste-heat boilers, or other heat-recovery equipment.

Profiting once more by lessons learned on the steam turbine-electric project, the designers held the developmental phases of this locomotive essentially to the power plant itself and to the use of higher horsepower per axle than that currently conventional on internally powered locomotives. Control of the power plant and the locomotive, the design of the transmission, and the locomotive design were patterned very closely after diesel-electric locomotive practice.

The power plant was built and adequately tested before construction of the locomotive. The locomotive, including the power plant, received exhaustive tests in Erie and preliminary tests on two Eastern railroads. It was then placed in revenue test service on the Union Pacific Railroad and has been in operation on that system for approximately a year and a half.

During this period, the locomotive has operated over nearly all of the main lines of the Union Pacific between Omaha and Los Angeles, covering elevations from 16 to 8014 ft and ambient temperatures ranging from −8 F to 117 F. It has been used in average freight service in this territory, although practically no local freight trains have been handled. Tonnage of the trains hauled has been dictated by motor ratings on long sustained grades. On short grades, the locomotive has successfully handled 4500 tons on a 1.25 percent grade and 6500 tons on a 0.7 percent grade.

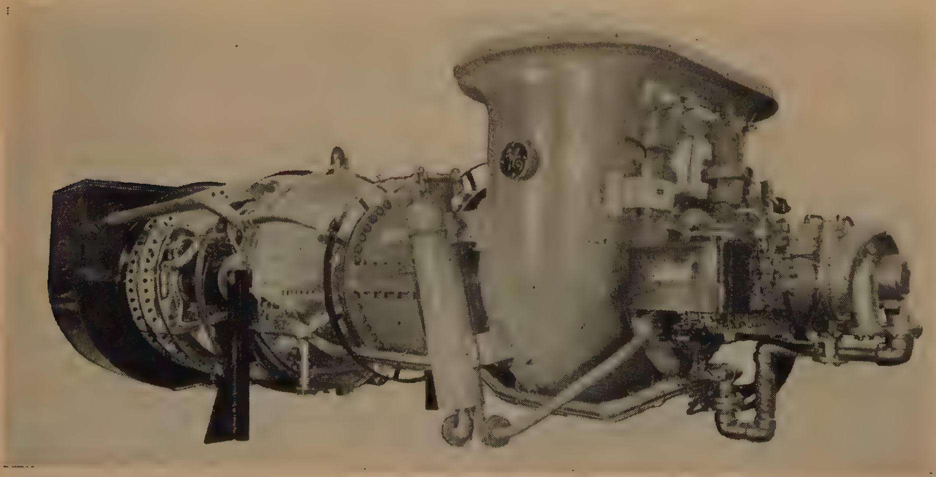


Arrangement of equipment inside the gas turbine-electric locomotive

PERFORMANCE

From the train-handling standpoint, the performance of the locomotive has been quite satisfactory. It demonstrated its ability to start and handle its tonnage under all the operating conditions which it has encountered. Adhesion characteristics have been very good, and the power output has exceeded the original estimates.

In territory where long sustained grades dictated the train weight, the locomotive was at a disadvantage in comparison with the conventional low-horsepower-per-axle locomotives. Even though operating speeds on the grades were higher and the full power output could be used, traffic and yard delays practically offset the higher operating speeds. In territory where the train weight was dictated by grades of not over 0.8 percent



Power plant for the gas turbine-electric locomotive e locomotive was able to haul all the tonnage which ould be handled with existing siding and yard facili- es. Under these conditions it gave a very satisfactory count of itself.

The locomotive has been operated a total of 85,000 iles, and has produced a total of 285,389,000 ton- iles, nearly all of which has been in revenue test rvice on the railroads. Experience during this time as indicated that the availability of locomotives of is type can be high. The test unit has shown avail- bility approaching 80 percent at various times during s operation.

ROGRESS

A great deal of progress has been made in correcting e minor troubles experienced early in the test period. here has been a marked improvement in combustion- amber life; fuel handling and cleaning, which gave good deal of trouble, are now approaching satisfactory peration; electrical troubles have been negligible; ower-plant starting has come to be a routine opera- on. At first the power-plant auxiliaries were responsi- le for numerous difficulties, but now they rarely give ouble. Tunnel operation so far has been quite satis- ctory.

Some difficulty has been experienced in handling and urning certain heavy fuels; it is still necessary to find ut which fuels can be burned satisfactorily and which els give trouble. At present it seems that the vanadium ontent of some of the heavy fuels is responsible for any of these problems, and intensive study is being ade of the use of various additives to combat the ouble. Further testing is necessary on fuels, cold- eather operation, and operation in heavy snow. here are also a number of refinements required on ieces of equipment which will need considerable sting.

Operating-cost figures, even after a year and a half road-service testing, still mean relatively little. uch of the operation has been on special fuels for ecial test purposes. No heavy maintenance has been one. However, taking the operating costs as compiled, dding an estimated cost for heavy maintenance, and omparing the results with average diesel-electric loco- otive operations indicates that operating costs of the as turbine-electric locomotive may bear favorable omparison to those of its diesel-electric brother.

The acceptance of this radically new locomotive by ilroad operating and maintenance personnel has, in eneral, been very good. Operators particularly like its mple control and its ability to develop high starting active effort. Those responsible for its operation and aintenance feel that, with some refinements, the aintenance charges can be kept low enough and the ailability high enough to produce favorable operating osts. By purchasing ~~ten~~ 3 units for freight service, the nion Pacific Railroad has shown its confidence in this ew type of motive power and taken the initiative in rther evaluating the gas turbine-electric locomotive r American railroad operations.

DESIGN ENGINEERS

CAN YOU USE A RESISTANCE MATERIAL in which *I varies as E*^{4}?

Thyrite may be the answer to some of your circuit problems. It is a silicon-carbide ceramic material, dense and mechanically strong, having nonlinear resistance characteristics—the resistance varying as a power of the applied voltage. Its resistance characteristic is stable, and substantially independent of polarity or frequency. Thyrite® has been used for many years in important applications, including electronic. It can be produced in various shapes and sizes (those which can be successfully molded).

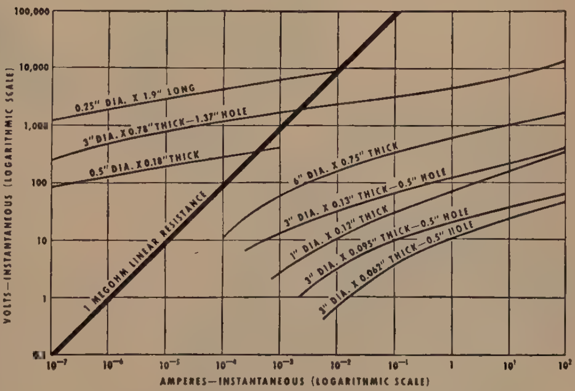
Some of its MANY APPLICATIONS

For protective purposes (to limit voltage surges).

As a stabilizing influence on circuits supplied by rectifiers.

As a potentiometer. (The division of voltage can be made substantially independent of load current.)

For the control of voltage-selective circuits, either independent of or in combination with electronic devices.



Typical volt-ampere characteristics of Thyrite resistors of several resistance levels and power ratings. Note that the nonlinear voltage-current characteristic extends over an extremely wide current range. Compare it with the characteristic (heavy line) of a 1-megohm linear resistor. Apparatus Dept., General Electric Company, Schenectady 5, N. Y.

Contact your nearest G-E office for additional data or address Transformer & Allied Product Divisions, General Electric Company, Pittsfield, Mass.

GENERAL ELECTRIC

405-13

Tops

LIKE SPEER MULTIFLEX BRUSHES

For Better Contact

SPEER *Carbon* **CO.**

ST. MARYS, PENNSYLVANIA

Subsidiaries

Speer Resistor Corp.—International Graphite & Electrode Corp.
Jeffers Electronics, Inc.

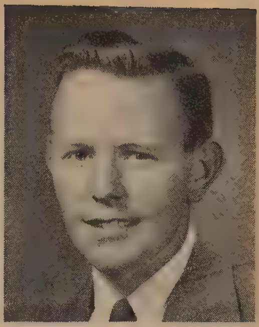
U.S. Pat. 2,181,076

7274

UTDOOR PLANT LIGHTING

Outdoor plant lighting technique as a vital factor in minimizing waste and increasing manufacturing efficiency in today's program of sharply accelerated production schedules

By J. S. LINDSAY
Lighting and Rectifier Divisions
General Electric Company, Lynn, Mass.



J S Lindsay

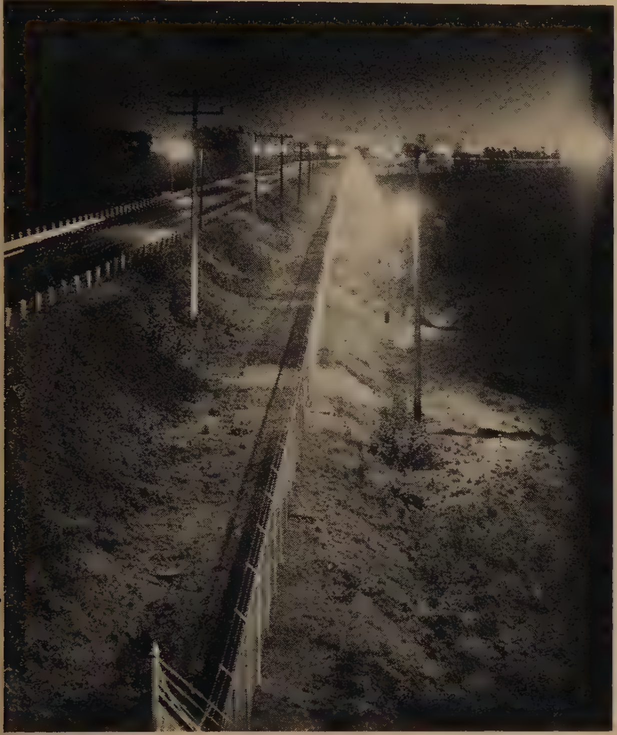


Fig. 1. Protective lighting of boundary fence by the glare projection system. Luminaires, designed to give a two-way light distribution, are mounted at a height of 25 ft on poles spaced 150 ft apart

THE impending manpower and material shortages have given new importance to adequate outdoor ant lighting. Engineers, determined to meet America's astly increased defense production schedule, regard tdoor plant lighting as a vital technique to minimize aste and increase manufacturing efficiency. Plants raining to meet unprecedented production quotas are panding their present lighting systems to accommote more night laborers, increased round-the-clock aterials handling, and tightened security regulations.

Determining the lighting requirements of each indidual intraplant area is only half of the engineer's job. he other, and most important half, is the co-ordinan of the individual lighting requirements into a basic tdoor-lighting plan for the plant as a whole.

The over-all lighting plan should be so integrated ith the industry's development program that the lighting system can be expanded to meet the needs of increased production, as well as a plant's physical growth.

By supplying enough light in every area where it is needed, over-all planning minimizes accidents to personnel, equipment, and material. At the same time, unnecessary duplication of light, which often results from haphazard or piecemeal planning, is avoided. Thus, an over-all lighting plan prevents wasted power consumption.

BOUNDARY LIGHTING

The initial consideration in outlining a protective lighting plan for industries with a high security classification should be boundary or fence lighting. Adequate fence lighting helped establish an encouraging record during World War II.

A "glare projection" system has been developed for boundary lighting which not only reveals intruders but effectively handicaps their vision. This system requires luminaires which are designed to give a two-way light distribution. The units are so mounted that they project light up and down the boundary line with a relatively high angle of maximum candlepower. The effect is to "blind" trespassers approaching the boundary lines from the outside. When properly mounted, this system projects a band of light approximately 20 ft wide on each side of the fence.

To meet minimum foot-candle requirements for boundary fences, the luminaires should be mounted on poles positioned from 12 to 15 ft within the fence line. The luminaires should be mounted at a height of 25 ft with a 25- to 30-deg angle tilt from the vertical. Experience indicates that an average linear spacing of approximately 150 ft between each luminaire affords excellent visibility for the guard and satisfactory distribution uniformity. The two-way pattern of light furnished by each luminaire assures an overlap of light between poles. This overlap is necessary to maintain sufficient illumination in the event of a burn-out or lamp failure of one unit.

Fig. 1 shows how an area of approximately 20 ft on each side of the fence is illuminated to a 0.2 ft-c average. Actually, the area up to 70 ft outside the fence line is well above the "moonlight" level. Such a method of fence lighting provides a sharp cutoff close to the pole.

This article is so paged that, without mutilating other articles, it can be dily removed for filing as a group of full-size consecutive pages.—EDITOR

This helps to conceal the guards who patrol the boundary lines and, at the same time, reveals the would-be intruder in full, direct beams of light. The power consumption of such an installation is approximately 4 watts per linear foot. Either 6000- or 10,000-lumen filament lamps are recommended.

The control of this type of fence lighting should be so designed that one master switch will operate the entire system. This switch is usually located in the central guardtower or guardhouse.

The control and the distribution necessary for this system is especially well adapted to the series-type circuit. Constant-current transformers provide a well-regulated power source and assure good lamp life. Lights used in a series circuit are independent of secondary distribution disturbances, and the control equipment is kept at a minimum.

Certain boundary fences entail restrictions which might prevent the use of the glare projection lighting system. The restrictions are usually present when boundary lines are adjacent to highways, navigable rivers, or other traveled ways which would be made unsafe by the glare of projected light.

Supplementary floodlights directed perpendicular to the boundary lines are an excellent solution. The floodlights—usually wide-beam and equipped with 500- to 750-watt lamps—are mounted at heights of 25 to 30 ft on nearby buildings or poles. Often this multiple lighting can be taken from the series circuits by series multiple transformers or RIL series multiple relays which can control a secondary multiple circuit.

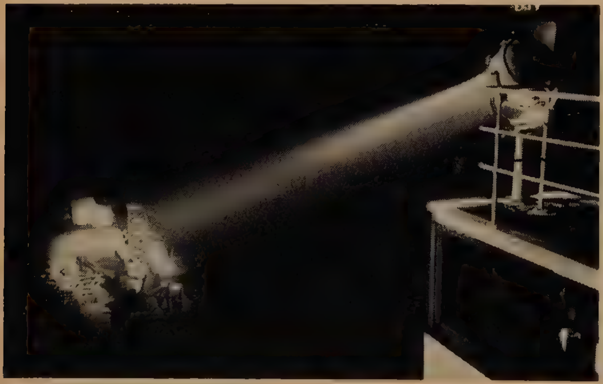


Fig. 2. Example of a searchlight mounted on a guardtower and controlled from the guardroom below

An important element of any protective system is the guardtower, each of which is located at a critical point along the boundary (Fig. 2). Searchlights, which can be controlled by guards in these towers, supplement the fixed lighting during emergencies. For this purpose, 14-, 16-, or 18-in. incandescent-type floodlights should be used. Equipped with 1000- or 1500-watt lamps, these searchlights are usually of the pilothouse control type, which can be placed on the roof of the guardhouse and controlled from the guardroom below.

Daytime and nighttime inspections should be made with the aid of local guards to obtain a complete survey of local conditions. Areas favorable to would-be intruders become apparent from an examination of the property. For such inspections, it is recommended that a map of the plant layout be utilized to mark up special areas. Often a well-designed effective lighting system will not only facilitate policing, but will also reduce the number of guards necessary for adequate patrolling.

SUBSTATION LIGHTING

To help insure a continuous and reliable source of electrical power—essential to keep our defense factories rolling—outdoor substations should be adequately illuminated (Fig. 3). In addition to hindering sabotage, sufficient lighting facilitates operation and maintenance of these units.

Normal substation lighting requires light to be directed toward the upper structure around the switching equipment. Luminaires are available which provide a distribution of upward light. These units—bracketed to the framework of the steel structure—are spaced to provide approximately 2 watts per square foot of ground bay area. This type of substation luminaire accommodates a 300- or 500-watt general-service filament lamp.

To establish the best lamp size, the engineer should determine the practical location of the luminaires, then divide the area to be lighted by the total number of luminaires. The quotient indicates the required wattage.

The area surrounding a substation should be lighted to approximately one foot-candle by wide-angle floodlights. These floodlights are mounted on wood or steel poles located near the corners of the property and directed toward the substation. In addition to providing a well-lighted area around the structure, this system

Fig. 3. Substation lighted by luminaires bracketed to the framework of the steel structure and spaced to provide approximately 2 watts per square foot of ground bay area

ig. 4. Example of a loading platform lighted by the pendent-type
ghts bracketed to the building

5. Mercury street-lighting units
ninate plant roadway

ntributes to the light level of the lower regions around
transformers. A minimum mounting height of 25 ft
recommended for these floodlights. Higher mounting
ghts result in a superior light distribution because
re is minimized and long shadows are eliminated.

RD LIGHTING

Internal yard-lighting levels around loading plat-
ms, storage spaces, parking areas, and entrances can-
be determined solely by an empirical formula
ing watts per area or illumination levels. The selec-
n and placement of lighting fixtures must also be
nsidered. Street-lighting luminaires and floodlights of
varieties are utilized.

Vorking areas and loading platforms around build-
s are effectively illuminated by street-lighting lumi-
res mounted on the buildings at a height of 26 to 28 ft
G. 4). Pendent-type units equipped with 500-watt
ment lamps are recommended; these units should
vide a symmetrical light distribution.

To facilitate accurate identification of materials, up
wo foot-candles of light are recommended for loading
tforms or outdoor working areas. Frequently these street-lighting luminaires are supplemented with wide-angle floodlights (500 to 750 watts) to eliminate shadows.

Certain areas in larger industrial plants are wasted because poor illumination prevents their nighttime use. Often these areas could be used as shipping or storage space, if adequate illumination were provided. One economical method of lighting areas such as these is to erect a tower or pole on which floodlights are mounted and aimed out radially.

INTERNAL ROADS

Roads within a factory should be illuminated at the same levels as well-traveled city thoroughfares. Adequate plant-roadway lighting reduces accidents, accelerates traffic flow, and affords workers a maximum of protection (FIG. 5). For such street-lighting applications, refractor-type optical assemblies are used; these direct a maximum of light onto the roadway pavement.

The paramount consideration is to increase the silhouette effect of dark objects against a light pavement. Generous luminaire overhang over the roadway is very effective in increasing the pavement brightness.

The mounting height and overhang are dependent on the type of luminaire and the lamp size. Other variables in plant roadway lighting are roadway width, the reflectivity of the roadway surface, and irregular roadway shapes. The plant engineer should consult the ASA Recommended Practice on street lighting to obtain recommendations on the type or quantity of equipment recommended to do an effective lighting job. Usually the minimum illumination requirements of plant roadways range from 0.2 to 1.2 ft-c.

Sufficient illumination is vital at entrances and exits to help guards in maintaining a steady flow of authorized people and material in and out of the plant (FIG. 6). Up to two foot-candles should be used at authorized entrances. This level is usually achieved by supplementing the illumination from street-lighting units with wide-angle floodlights. The floodlights, equipped

ASSOCIATED
ELECTRICAL
INDUSTRIES
• LIMITED •

British Thomson-Houston Co., Ltd.
Edison Swan Electric Co., Ltd.
(Incorporating Harcourts Limited)
Ferguson Pailin Limited
Hotpoint Electric Appliance Co., Ltd.
(Incorporating International Refrigerator Co., Ltd. and Premier Electric Heaters Ltd.)
Metropolitan-Vickers
Electrical Co., Ltd.
Metropolitan-Vickers-GRS. Ltd.
Newton Victor Ltd.

• •

Agents and Licensees of the
GENERAL ELECTRIC Co., U.S.A.
for the United Kingdom.

A3951

OUTDOOR PLANT LIGHTING

(Continued from preceding pag

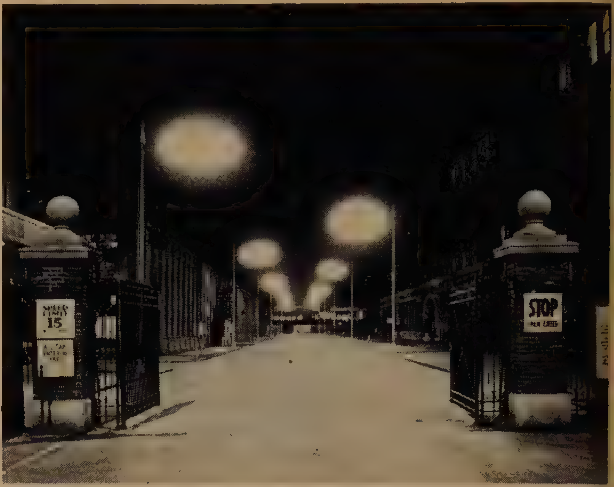
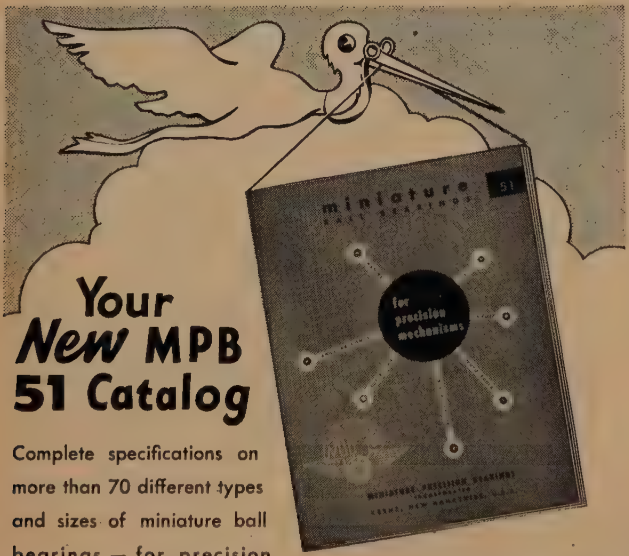


Fig. 6. Example of a factory entrance and plant roadway illuminated by pole-mounted street luminaires

with 1000- to 1500-watt lamps, are located approx mately 30 ft above the level of the entrance.

In simulating daylight working conditions, one or tw foot-candles of artificial light must be as functionall effective as the 10,000 ft-c provided by Nature. Applying this artificial light to assure maximum safety efficiency, and security, requires proper selection c equipment and a thoroughly engineered lighting prc gram.



Your New MPB 51 Catalog

Complete specifications on more than 70 different types and sizes of miniature ball bearings — for precision mechanisms presenting anti-friction, light weight, high load capacity, and other unusual conditions.

This new and expanded catalog contains complete and valuable information, including most recent developments on weights, loads, design data, applications and special bearings. Send for your copy today — ask for Catalog GR 51.

MINIATURE *Precision* BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE
"Suppliers to the World's Foremost Instrument Manufacturers"

Unit including dust cap, 1 $\frac{1}{16}$" dia. X ¾" d.

PRECISION *Controls*

Tapered winding to plus/minus 1½% linearity, measured at 10 points.

☆

Mechanical tolerances to plus/minus .00025".

☆

Immunity to temperature, humidity, altitude, vibration.

☆

Silver contact, contact rail, etc., for low-loss conductivity.

★ Yes, *precision!* This potentiometer was de signed, tooled and produced as a Clarosta *special*. Intended for a highly-critical electroni assembly. Please remember that in additio to its outstanding variety of controls an resistors, Clarostat is always ready to de velop and build special units for extraordi nary requirements. ★ *Submit that problem!*

CLAROSTAT *Controls and Resistors*
CLAROSTAT MFG. CO., INC. DOVER, N. H.

The case of the voracious

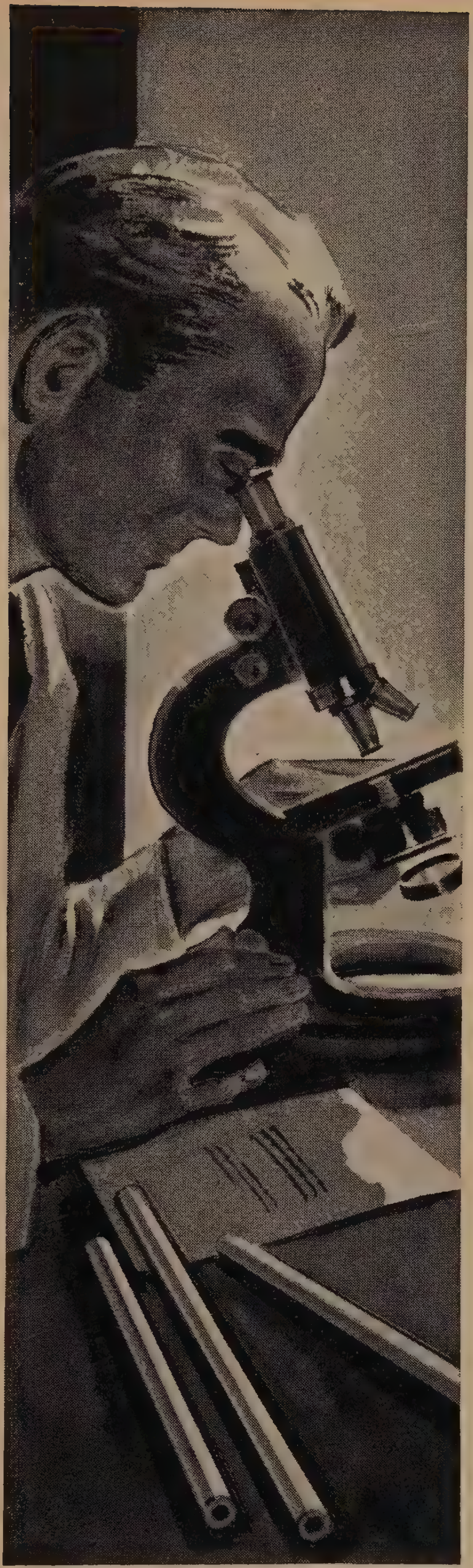
cooling water

Inlet-end corrosion of a rather vicious character was causing rious trouble in the condenser tubes of a rge power company's seaboard plant.

With the utility's engineers, Anaconda set a three and one-half year test of the corro- e action of the cooling water used at this ant on a variety of tube materials, including dmiralty alloys, aluminum brass and alumi- m bronze, and copper-nickel alloys.

At the end of this period, careful observa- n and analysis of results proved Ambraloy 7 (Anaconda aluminum brass) to be most vantageous in over-all performance and cost this application.

This story describes a typical service by Anaconda's Technical epartment. Through this department, Anaconda has saved oney and trouble for many utilities and industrial companies ced with condenser and heat exchanger problems. May we help u? The American Brass Company, Waterbury 20, Connecticut. Canada: Anaconda American Brass, Ltd., New Toronto, Ontario.



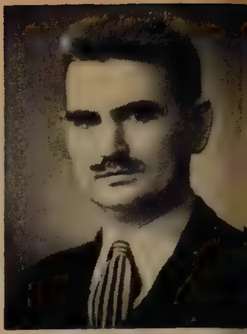
for efficient heat transfer

ANACONDA®

HEAT EXCHANGER TUBES

50124

INDUSTRIAL USES OF ULTRASONICS



George E Henry

Many different applications of sound energy to industrial purposes have been attempted, and even more proposed. Here are some of the possible fields of application, with special attention to its use for the industrial cleaning of metal parts

By G. E. HENRY

General Engineering Laboratory
General Electric Company

SINCE sound waves can be generated and transmitted in gases, liquids, or solids, one might guess immediately that a great variety of uses should be found. A classification based upon the three different states of matter is desirable not only for obvious, everyday reasons, but also because the sharply different acoustic impedance characteristics, as between gases and liquids or solids, require the engineer to utilize different kinds of drivers, or generators, for getting the sound into the material.⁽¹⁾ Other classifications depend upon frequency range and the power level to be used.

FIG. 1 is a plot showing all kinds of sound signals, placed according to their intensity (ordinate) and frequency (abscissa). Both scales are logarithmic, to represent each frequency or intensity band by an amount of space in keeping with the true importance of that band. The familiar region of everyday audible sound is seen to lie near the center of the chart. Below and at the left of this area, the sound is too weak or too low-pitched to be heard. Above it, the sound is loud enough to be painful or even injurious to the hearing mechanism. Shaded in, at the right of the 15-kcps line, lies the ultrasonic region. This extends all the way from the bottom to the top of the chart, for, by definition, the term "ultrasonics" denotes simply those sounds whose frequency is above the audible range.* Th high-power region lies across the top of the chart. Bot of these shaded areas are of interest, and the area overlap *C*, in the upper right corner, will prove particular significance.

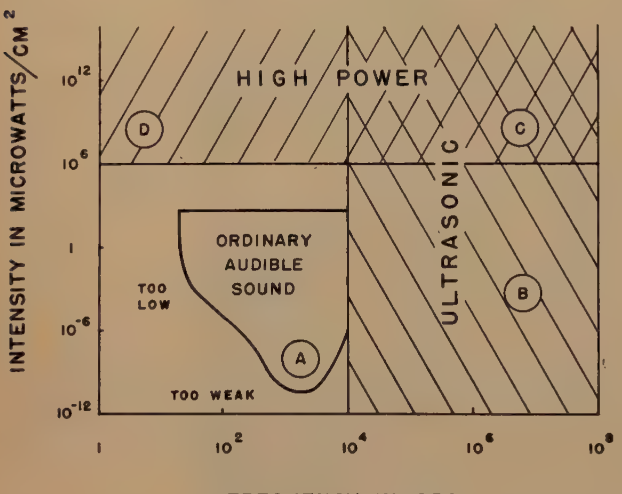


Fig. 1. Intensity-frequency plot of sound signals. The high-power ultrasonics region *C* is of particular interest in industrial experiments

The distinction between the low-power application of sound (such as measurement and signalling) and th high-power applications (industrial processing) fairly clear. One may cite the analogy with electrica engineering, where power engineering constitutes on distinct field and communications, or "weak-curren engineering," another. In the acoustic case, howeve nearly all the pioneer work was prompted by the nee for measurement or signalling devices. Hence, th low-power applications developed rapidly during th period between the wars, while high-power soun remained an interesting curiosity. This latter fiel however, seems now to be coming into its own.

The distinctions based upon frequency are als important. The familiar uses of the audible range (fo speech, music, or signalling to living creatures) are no of concern here; we may define industrial sound a sound which is designed to act upon some nonauditor receptor system. And it turns out that for most suc applications the ultrasonic frequency range offe important advantages. In fact, the term ultrasonic itself is often used loosely, as if it were synonymou with industrial sound.

FIG. 2 presents a few typical applications, arrange according to power requirements and according to th acoustic medium involved. The first classification, low power sound in air, includes such items as the acoust relay for opening a garage door. This is an interestin novelty, but one which has to compete with other de vices, such as magnetic relays, serving the same purpos

Sound could be used in a number of different way for burglar-alarm systems, or for human safety de vices, and some interest is currently being shown this type of application.

The field of sonar, or sound echo ranging, is bein thoroughly explored. We have an excellent sample this in nature: the flight control of bats. It is no definitely established that these creatures guide the movement through the air by performing a runnin echo-range analysis of the ultrasonic cries they pr

---

(1) Numbered references are listed at the end of the article.

*The upper limit of audition varies with the individual. The Americ Standards Association has established the value of 15 kcps as a suitable ar trary boundary between the sonic and ultrasonic frequency ranges.

INDUSTRIAL SOUND

	LOW POWER (Measurement & Signalling)	HIGH POWER (Processing)
	acoustic relays sonar	aerosol precipitation vermin eradication
	sonar, depth recording SONAR, FISHING AIDS interferometry process control	industrial cleaning sterilization chemical treatment homogenization aluminum soldering
	THICKNESS GAGE FLAW DETECTION	selective heating of inaccessible dissipative materials

lower case lettering: theoretically possible, may or may not be practicable

underlined lettering: applied in the laboratory, in pilot plant, or on small scale

CAPITAL LETTERS: REGULAR COMMERCIAL APPLICATION

Fig. 2. Present and possible future commercial applications of sound

ce. The result is a very efficient system—for bats. forts have been made to engineer something comrable to enhance the mobility and safety of blind ople. Valuable work has been done in this direction the Massachusetts Institute of Technology, at the skins Laboratories, and elsewhere; but the physical d psychological limitations inherent in the problem imposing. Only very high-frequency sound can be amed effectively from a source of practical size. But mospheric absorption of sound increases rapidly as frequency goes up; hence, a highly directional beam not able to travel far.

GH-POWER SOUND IN GASES

High-power sound can be produced in air by means sirens, and practical use is being made of this mecham to precipitate liquids and/or small solid particles m certain stack gases. This is one of the comparaely few illustrations of industrial sound at sonic quency. While much of the early developmental work s done in the ultrasonic range, it has now been found ctical to operate acoustic precipitation systems ween 1000 and 10,000 cps. Thus we see that, hisically, man's use of sound has followed a definite gression, in the counterclockwise direction around . 1: his first experience was only with audible sound gion *A*); this was followed by work with low-power rasonics (region *B*, 1915), then with high-power rasonics (region *C*, 1930), and finally with highver sonics (region *D*, 1945).

Very high sound intensities, however, are more ily obtained at the higher frequencies. Hence, the experiments on the killing of mice and other vermin, conducted at the Pennsylvania State College, made use of ultrasonics. Exposure for one minute to a sound field of 160 db at 20 kcps proved fatal to white mice, the lethal effect being due, apparently, solely to the temperature rise produced by the conversion of sound into heat energy. Such intensity levels are apt to be uneconomical at low frequency.

LOW-POWER SOUND IN LIQUIDS

The usefulness of low-power sound in liquids is largely due, in one way or another, to the short wavelength associated with the high frequencies. Sonar, to be effective, requires a highly directive sound field pattern; this may be obtained only by making the wavelength small compared to the dimensions of the radiator. FIG. 3 shows a way of calculating approximately what the dispersion cone will be. The example presents the case for a radiator of 2-in. diameter, operating at a frequency of 120 kcps; at frequencies in the high-megacycle range a beaming effect comparable to that of a flashlight may be had.

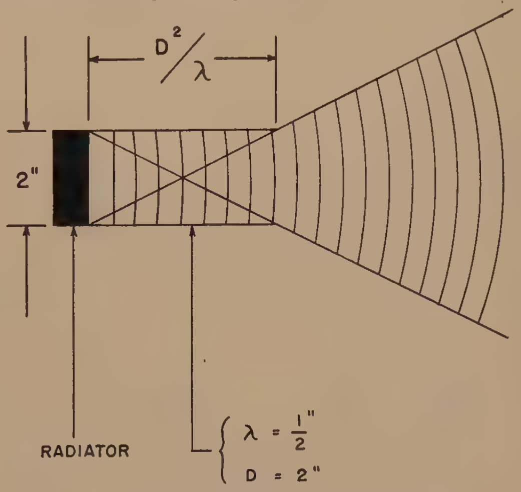


Fig. 3. Approximate method for determining the dispersion of the sound field from a radiator

Also, for purposes of interferometry, the short wavelength of ultrasonic frequencies is desirable. Since the half-wavelength (or sometimes the quarter-wavelength) is the real unit of measurement in interferometry, the use of ultrasonics gives us, in effect, a finely divided scale. A typical use of the interferometer is that of determining the velocity of sound in a liquid. This is accomplished by accurately measuring the half-wavelength at a known frequency.

HIGH-POWER SOUND IN LIQUIDS

This next classification, which may in the end prove the most important of all, calls for the use of sound not merely to measure something, but to bring about a change either in the liquid itself or in the surface condition of a solid immersed in the liquid. These applications have been of particular interest in the General Engineering Laboratory, where experiment has revealed a number of promising possibilities in the field of industrial cleaning. Some of these are no longer mere possibilities: ultrasonic generators are even now in process of being built into manufacturing production lines.

Industrial cleaning of metal parts commonly requires the use either of alkaline cleaners or of hydrocarbon solvents. Chlorinated hydrocarbons are especially effective, and are widely used in the vapor-degreasing process. It is well known that the action of both types of cleaner can be considerably enhanced if during the immersion of the solid work piece the liquid is irradiated with high-energy sound. This effect has been proved many times, with different materials, by the use of an ultrasonic generator. The instrument, shown in Fig. 4, consists of a power oscillator and matching coil assembly, plus the quartz transducer and liquid treating chamber located in the housing on top of the cabinet.

A close-up of the transducer is given in Fig. 5; the liquid treating chamber, of about an inch and a half diameter, can be seen in the center of the housing. The upper face of the quartz crystal forms the floor of the chamber. An insulating and cooling oil bath occupies most of the space inside the outer plastic shell and, in the picture, greatly magnifies the quartz crystal and its rubber mounting by optical refraction.

Since the treating chamber holds about a half cup of liquid, the sound-intensity level, built up by reverberation, becomes very high indeed. The acoustic output of the crystal is in the vicinity of 200 watts, and this figure necessarily represents the rate at which sound energy is dissipated in heating the liquid, the housing, and surrounding air. But since the energy stored elastically in compression of the liquid must be reflected several times before it is absorbed, it is clear that the intensity level must be well above the nominal value of 15 watts per cm^2 arrived at by dividing the total acoustic output by the area of the crystal face.

For special purposes, larger treating tanks have been built and used with this unit, to accommodate larger work pieces. This is sometimes justified, but generally it is desirable to obtain as high an intensity level as possible while using the minimum input power. This calls for small volumes of liquid; and at the lowest ultrasonic frequencies it may even require a careful adjustment of the height of the liquid column to an odd number of quarter-wavelengths, tuning the acoustic system for optimum loading of the transducer.

Thus it appears that ultrasonic cleaning looks most promising for small metal parts—parts of relatively high value, requiring a really thorough cleaning. For such parts, the fact that cleaning may be speeded up in a ten-to-one or even a hundred-to-one ratio is highly significant. The improved quality of cleaning may be even more important. An ultrasonic cleaning may sometimes be the only satisfactory way of removing oil, grease, and lapping compound from capillary spaces in small mechanisms. The effect here is perhaps comparable to that which has been observed in the study of the high-intensity air siren.(2) If a hand is placed in the sound beam from the siren, the fingers are immediately burned, provided they are held not quite touching. Outspread fingers, however, are not burned—at least not immediately. A reverberation or diffractic phenomenon appears to be applicable both to tl small spaces between fingers exposed to air-borne soun and to the small spaces, for example, between a ste block and a piece of thin sheet metal tack-welded to i

Ultrasonic cleaning may offer a distinct advantage another sort, in permitting a wider choice in the sele tion of lapping compounds, or of rouge buffing cor pounds. It is common knowledge that the preferen for one buffing compound or another is based not on upon how well it will do its job, but also on ho effectively it can be removed after the job is don Unfortunately, some of the best compounds are tl hardest to get off afterward. But ultrasonics w usually remove even the most obstinate. One can a cordingly select processing materials on the basis effectiveness alone, perhaps at considerable gain to tl appearance and precision of the finished article.

THEORIES RELATING TO ACTION OF ULTRASONICS

Much uncertainty still exists as to the manner which the sound energy accomplishes the cleanir result. It has been known for some time that ultr sonics produces fine dispersions of one liquid in anothe and the catalysis of certain chemical reactions, notab oxidation, has often been reported. The saponificatic process is known to be speeded up by acoustic irradi tion; this accounts, apparently, for the effectiveness ultrasonics in an alkaline cleaning solution. But it remai to be explained why the catalytic action should occu

Many of these effects are now thought to be a co sequence of cavitation, rather than of the sound wa itself. Cavitation has been variously defined; for our pu poses it is the alternate formation and collapse of bubbl

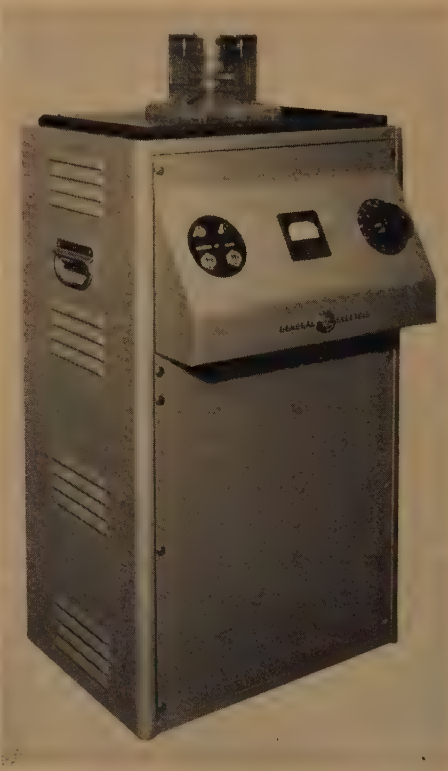


Fig. 4. Ultrasonic generator

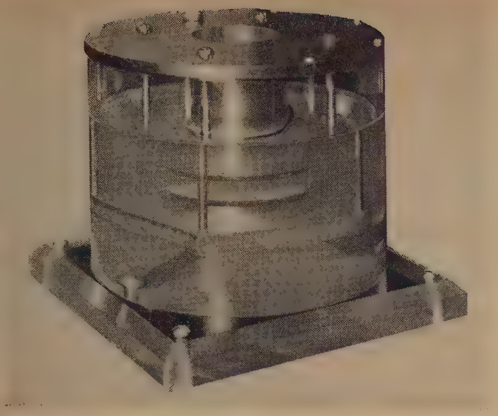


Fig. 5. Transducer assembly that is mounted on top of the generator control cabinet

liquid medium. Some of its manifestations, such as erosion of ship propeller blades, are all too familiar. o see how cavitation is produced by a high-power ıd source in a liquid, assume a piston serving also he floor of the container of the liquid. As the piston es up, the fluid is compressed and the sound wave els upward. On the down stroke, the liquid im- iately in contact with the piston at first stretches ıtly, while its pressure is at the same time drastically ıced. When the pressure drops to the vapor pressure ıe corresponding to the existing temperature, the id boils and fills with gas the cavity being created the downward motion of the piston—provided, ever, that favorable conditions exist for the forma- of vapor bubbles upon solid surfaces, or upon al- ly available nuclei, in the form of dissolved gas in liquid. When such favorable conditions do not exist, vapor is not able to form, and there is then nothing heck the further pressure drop of the liquid, which proceed on down to negative values of absolute sure. Theory shows that pure water may support ydrostatic tensile stress as high as 1300 atmos- res, while some tests have produced values above atmospheres.(3)

nce water and other liquids nearly always contain urities, particularly dissolved gases, it is apparent large negative pressure values will not usually be hed. On the contrary, vapor bubbles will be rapidly ned as the piston moves down, and as rapidly ıpsed on the up strokes. Thus a "cavitation layer" ıs at the liquid-solid boundary. This layer has an lating effect, and prevents the transfer of large unts of sound power into the liquid. One may say the body of liquid merely rides the crests of the roke of the piston, and accordingly presents a rela- y low load impedance. This difficulty can be par- y overcome by subjecting the liquid to pressure.

he preceding description fits the case fairly well at cps, with a piston travel of one ten-thousandth of an . But as the frequency is increased, with the vibra- velocity of the piston kept constant, the accelera- increases linearly with frequency, while the dis- ement decreases correspondingly. A point is reached hich the liquid apparently remains in contact with the piston face, and cavitation, as previously defined, does not occur. The stretching force on the liquid is strongly present, however (accelerations are now much higher than before), and a pattern of violent agitation is distributed more or less uniformly throughout the liquid. This rapid fluctuation in pressure, ranging through values measured perhaps in dozens of atmospheres, may well account not only for the destructive results of cavitation but also for its effectiveness in cleaning small metal parts.

OTHER APPLICATIONS

The use of low-power sound for flaw detection in solid bodies is now an industrial commonplace. Meanwhile, there are prospective new developments. Consideration is given here to two prospective developments in the high-power classification. One of these has to do with the tinning of aluminum, without the use of flux, by soft solder. It has been found that the characteristic oxide film on aluminum, which normally prevents wetting of the metal by the solder, loses this insulating property when vibration is applied, with the result that firm bonds are established between solder and work piece.

Finally, there is the recent report on acoustic diathermy from the Mayo Clinic, Rochester (Minn.). Physiologists there, using 15 watts of 800 kcps, successfully heated the bone and bone marrow of animals under study while effecting only a very slight temperature rise in the surrounding tissue. Sound was beamed into the animal from a quartz crystal in contact with the skin. Because of the high damping, or dissipation characteristic, of bone as compared to muscle tissue, the conversion of sound to heat occurred almost wholly within the bone. It is not unreasonable to hope that comparable opportunities for selective heating will be found in industry, supplementing the already well-developed systems for induction and dielectric heating.

REFERENCES

(1) "Equipment for Generating Ultrasonic Energy," by W. H. Janssen, *Chem. Eng. Progress*, Oct. 1950, vol. 46, No. 10, p. 537 (also GER-332).

(2) "Some Biological Effects of Intense High-frequency Airborne Sound," by C. H. Allen, H. Frings, I. Rudnick, *Jour. of the Acoustical Society of America*, Jan. 1948, vol. 20, No. 1, p. 62.

(3) "The Fracture of Liquids," by John C. Fisher, *Jour. of Applied Physics*, Nov. 1948, vol. 19, No. 11, p. 1062.

SEXTON CAN COMPANY
Incorporated
Everett Massachusetts
Manufacturers of
Ash Barrels
Kitchen Waste Cans
Underground Garbage Receivers

CAPACITOR CASES
both Fabricated and Deep Drawn
FIVE GALLON
Open and Closed Top Shipping Containers

METAL STAMPINGS
SPECIAL SHEET METAL WORK

CORROSION CONTROL FOR COOLING SYSTEMS OF ELECTRIC APPARATUS

A positive yet economical means of preventing a corrosion problem, particularly applicable where iron is present in the cooling system

E. J. Remscheid

By EMIL J. REMSCHEID
Industrial and Transmitting Tube Division
General Electric Company

IT IS not always practical or even economical to construct cooling systems, for electrical apparatus, of noncorrosive metals. The many evils which accompany a corroded metal surface are often tolerated because, in choosing the metal, its corrosive nature is of secondary importance. A steam boiler is essentially constructed of iron, and when in operation, water will be in contact with one of its heat-conducting surfaces. The design engineer finds that iron meets the boiler requirements better than other metals.

Experience has proved that iron is usually the most practical and most economical metal to be used in the fabrication of machines. Likewise, water when available in sufficient quantities, is ordinarily the most practical and economical medium for controlling the temperature of machines.

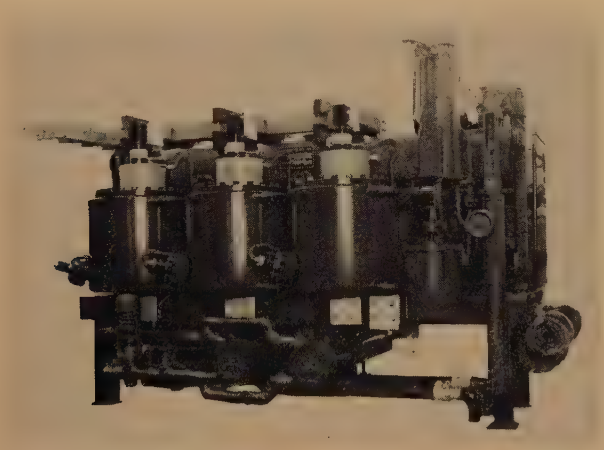


Fig. 1. A 1674-kw 515-volt pumped ignitron mercury-arc rectifier

THE CORROSION PROBLEM

The application of water in contact with iron presents to the manufacturer and operator of electrical apparatus, the so-called "Corrosion Problem." This problem presents itself in varying degrees, occasionally of no consequence, but sometimes, if corrosion is not retarded, considerable damage results. This damage may result in interrupted service or expensive repairs. The performance or the service life of electrical or mechanical apparatus of the present day should not be determined by the corroding away of the water-cooled iron pa
Corrosion has the faculty of starting a chain reaction
troubles. To begin with, the heat transfer efficiency o
water-cooled surface is impaired when it is corrod
Loose metallic oxide particles, flowing in a coola
stream, will clog pipes and cause erosion of water pu
impellers. Sensitive bulbs of thermometers, or therm
couples, installed for indicating temperature or p
tecting a machine do not tell the true story and cann
function as intended when coated with corrosi
sediment.

The corrosion problem is an economic one dependi
on the service life expected of a particular piece
apparatus. Service life can be built into a water-cool
machine, by providing extra thickness of iron to wat
cooled surfaces, by providing corrosion-free met
where desirable, or by insuring that the coolant is
nature noncorrosive.

The temperature of steel-tank power rectifiers
early manufacture was controlled by direct tap wa
cooling, using whatever water was available for t
purpose. In locations where water from city mains w
not available, wells were provided near the station.
the quantity of water available rather than its quali
was the criterion, many of the waters corrosive
nature were used as a coolant. The more corrosi
water attacked the iron parts of the rectifier, and su
sequently advanced stages of corrosion were not
several instances resulting in vacuum leaks in t
rectifier and water leaks in parts of the cooling syste

Careful studies of corroded areas indicated that p
ting corrosion was causing greater damage than the
called general corrosion. In general corrosion, the ano
and cathodic areas are fairly evenly distributed and
attack is slow. In pitting corrosion, the anodic area
small and surrounded by large cathodic areas.
virtue of its operation, the vacuum tank of a recti
develops potential differences across its surface. Th
potential differences, though small, are sufficient to
courage pitting corrosion. The concentrated attack
pitting corrosion will perforate the steel plate o
vacuum tank in a comparatively short time.

The rate at which corrosion develops is greatly
creased with increase in temperature. This is due mai
to the fact that both the electrical conductivity of

rolyte and the rate of chemical action increase
temperature. It is for this reason that water-
d iron parts operating at a temperature of 50 C
ide a fertile field for corrosion.

udies made of corroded surfaces, and the results of
al corrective measures resulted in the application
rrosion control. The successful application of cor-
n control(1) during the past 20 years as revealed in
ent survey of rectifier users in the United States
Canada, indicates that the service life of water-
d rectifiers can be increased indefinitely.

TION TO SOME CORROSION PROBLEMS

modern mercury-arc power rectifier(2) consists of
r six or twelve water-jacketed vacuum chambers
s. 1 and 2). Excess heat is removed by circulating a
ant through a steel or stainless-steel jacket or
ugh copper coils fastened rigidly against the ex-
al wall of the vacuum chamber. Each vacuum tank
is provided with one graphite anode and a mercury cathode, the main elements for the rectifying action. For the group of tanks comprising the rectifier, the auxiliary equipment consists of a transformer connected to supply power to the rectifier tanks in the desired phase relation, a firing circuit designed to energize the ignitor of each tank at the proper instant, an exhaust system which evacuates the tanks to a high degree of vacuum, and a water-cooling system designed to maintain the tanks at a prescribed operating temperature.

Reliable temperature control is one of the important requisites for good rectifier performance.

THE DIRECT RAW-WATER COOLING SYSTEM WITH RECIRCULATION

A direct raw-water cooling system with recirculation for power rectifiers consists essentially of a recirculating coolant flow through the various water jackets and a water-to-water heat exchanger, with a tap water source for cooling the heat exchanger, as shown in Fig. 3. Tem-

---

Numbered references are listed at the end of the article.

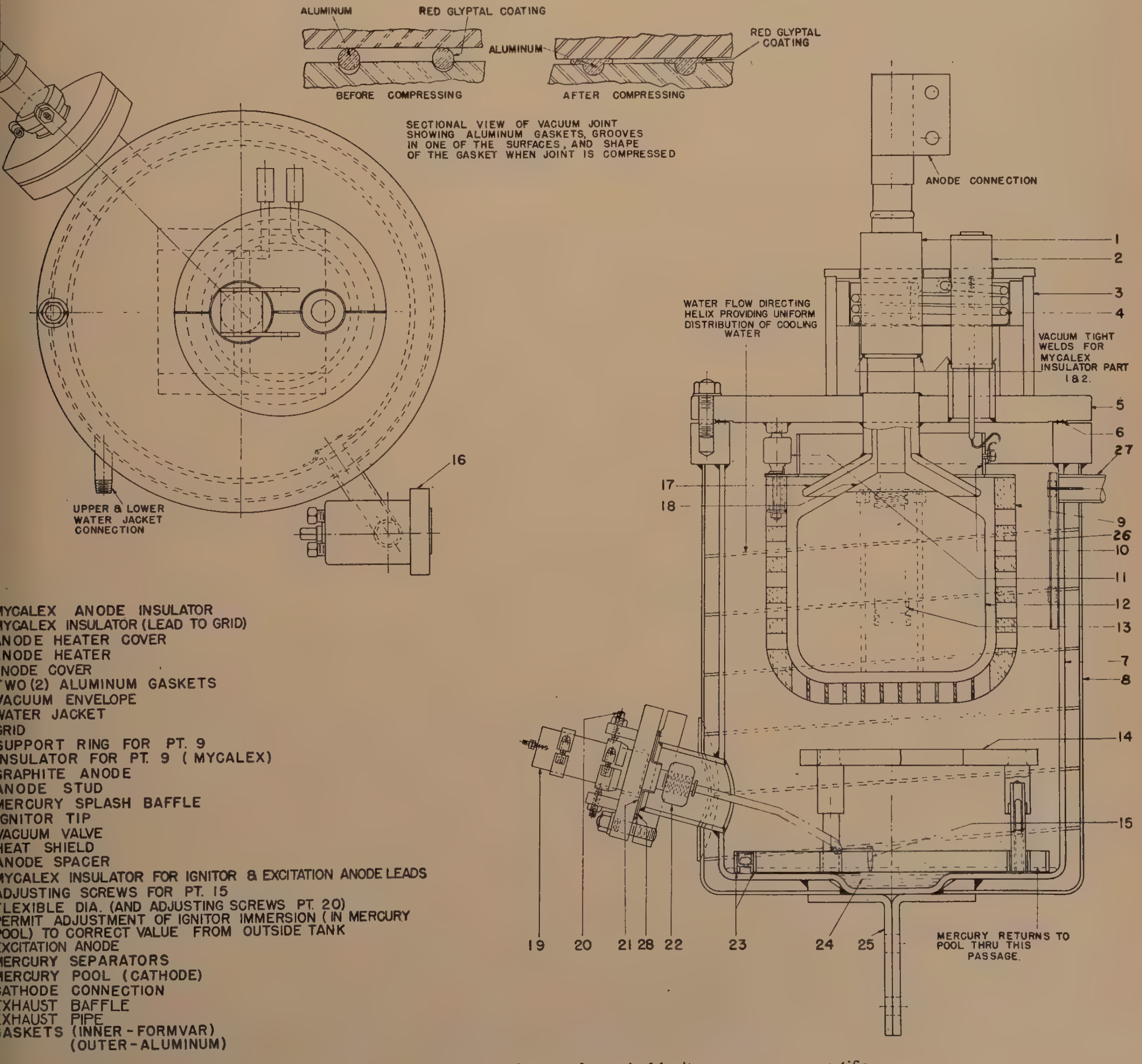

ALUMINUM
RED GLYPTAL COATING
ALUMINUM
RED GLYPTAL COATING
BEFORE COMPRESSING
AFTER COMPRESSING
SECTIONAL VIEW OF VACUUM JOINT SHOWING ALUMINUM GASKETS, GROOVES IN ONE OF THE SURFACES, AND SHAPE OF THE GASKET WHEN JOINT IS COMPRESSED
ANODE CONNECTION
WATER FLOW DIRECTING HELIX PROVIDING UNIFORM DISTRIBUTION OF COOLING WATER
VACUUM TIGHT WELDS FOR MYCALEX INSULATOR PART 1 & 2.
1
2
3
4
5
6
27
9
26
10
11
12
13
7
8
14
15
16
17
18
UPPER & LOWER WATER JACKET CONNECTION
19
20
21
28
22
23
24
25
MERCURY RETURNS TO POOL THRU THIS PASSAGE.
YCALEX ANODE INSULATOR
YCALEX INSULATOR (LEAD TO GRID)
NODE HEATER COVER
NODE HEATER
NODE COVER
WO (2) ALUMINUM GASKETS
ACUUM ENVELOPE
ATER JACKET
RID
UPPORT RING FOR PT. 9
NSULATOR FOR PT. 9 (MYCALEX)
RAPHITE ANODE
NODE STUD
ERCURY SPLASH BAFFLE
GNITOR TIP
ACUUM VALVE
EAT SHIELD
NODE SPACER
YCALEX INSULATOR FOR IGNITOR & EXCITATION ANODE LEADS
DJUSTING SCREWS FOR PT. 15
LEXIBLE DIA. (AND ADJUSTING SCREWS PT. 20)
ERMIT ADJUSTMENT OF IGNITOR IMMERSION (IN MERCURY
OOL) TO CORRECT VALUE FROM OUTSIDE TANK
XCITATION ANODE
ERCURY SEPARATORS
ERCURY POOL (CATHODE)
ATHODE CONNECTION
XHAUST BAFFLE
XHAUST PIPE
ASKETS (INNER - FORMVAR)
(OUTER - ALUMINUM)

Fig. 2. Arrangement and definition of parts of a typical ignitron mercury-arc rectifier

perature control of the recirculating coolant is maintained by an automatic water valve, in the tap water supply to the heat exchanger, with its sensitive bulb in the circulating coolant. The circulating coolant system is provided with electric water heaters which automatically maintain a minimum coolant temperature, a water-pressure relay for protection against failure of coolant flow, and the thermostats for protection against abnormal coolant temperatures. Because the recirculating system operates at rectifier potential, it is necessary that tap cooling water be conducted to the heat exchanger through insulating coolant conductors.

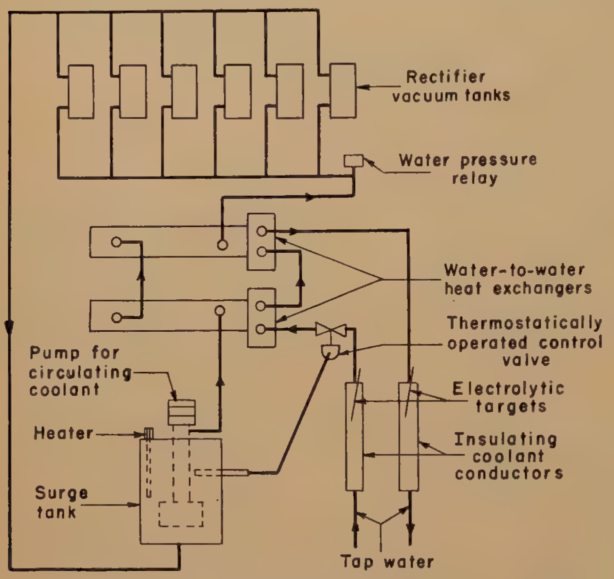

Rectifier vacuum tanks
Water pressure relay
Water-to-water heat exchangers
Thermostatically operated control valve
Pump for circulating coolant
Electrolytic targets
Heater
Insulating coolant conductors
Surge tank
Tap water

Fig. 3. Diagram of a power rectifier cooling system. Heavy lines indicate the coolant circuits

DIRECT RAW-WATER COOLING FOR SEALED-TUBE RECTIFIERS

Many installations of the sealed-tube rectifier design are provided with nonferrous cooling systems, and are cooled directly with tap water. The rectifier tubes in such cases are provided with stainless-steel water jackets and the coolant conductors are of copper. While corrosion problems do not occur in such installations, the cooling system must be maintained free of scale and algae.

PUMPED RECTIFIERS HAVING NONFERROUS WATER JACKETS

Some of the earlier pumped ignitron rectifiers were designed with copper cooling coils soldered to the vacuum chamber to remove excess heat. This design was adopted primarily to use raw-water cooling on the tanks.

While such designs using noncorrosive piping appeared desirable at first, some objectionable features developed. The long piping of relatively small diameter, that was necessary to coil around the vacuum tank, clogged easily and was difficult to clean out. The efficiency of heat transfer from the mercury vapor to the water is not nearly so high for designs using soldered copper cooling coils as when the vacuum chambe
completely immersed in water, as is the case in
steel water jacket designs.

In addition to these factors, it was found that be
operation of larger-sized rectifiers resulted when wa
to-water heat exchangers were used, because they
vide much greater thermal stability of the rectifier
erating temperature. For these reasons the use
soldered copper piping for cooling pumped rectifiers
discontinued and the much simpler steel jacket
suitable corrosion inhibitors in the recirculating coo
chosen.

APPLICATION OF CORROSION CONTROL

Adequate corrosion control begins in the design st
of a coolant system. The use of a water-to-water h
exchanger localizes the area where impurities may
deposited from raw cooling water, in sections which r
be readily cleaned.

The tap-water circuit of a power rectifier cons
essentially of the heat exchanger, automatic wa
valve, and insulating coolant conductors. Beca
waters of various chemical composition are used,
tubing in the heat exchanger must be accessible
mechanical removal of water scale and easily repla
able. It is interesting at this point to note the extre
differences in chemical constituents (Table I) of vari
lake, river, spring, and well waters used as po
rectifier heat exchanger coolants.

TABLE I

CHEMICAL CONSTITUENTS OF WATERS USED AS COOLANTS

(Parts per Million)

		Max	Mi
Total Dissolved Solids		265	31
Silica	SiO_2	56	2.
Iron	Fe	0.35	0.
Calcium	Ca	51.6	28
Magnesium	Mg	11.6	7.
Sodium	Na	5.1	1.
Potassium	K	5.1	1.
Bicarbonate	HCO_3	146	14
Sulphate	SO_4	56	12
Chloride	Cl	22	0.
Total Hardness	$CaCO_3$	127	19

Such a list of extremes in chemical compositior
various raw waters indicates that the method
frequency of cleaning fouled heat-exchanger tu
depends on the nature of the deposit. Should calci
carbonate be the first to dissolve out on clean m
surface, then a loose sludge can be expected to fo
Should calcium sulphate deposit first, then a hard s
will result.(3) Waters containing a high chlorine cont
are conducive to the rusting of iron. In conjunct
with rusting of iron, tubercles are produced which
comparatively short time will cause the clogging
water passages. Compared to the metal removed
rusting, tubercles resulting from the process may ha
volume 20 times greater. Another detrimental agen

t exchangers is manganese dioxide. The small ount of this chemical in water that will cause trouble uch that it cannot be detected in the usual chemical lysis. The black particles of manganese dioxide are dually deposited out on the hot surfaces of the heat- hanger tubes and, within a period of weeks or nths, will produce a film which will greatly affect t transfer.

leaning of heat-exchanger tubes must be done iodically, depending on local conditions. Reports in- ate the cleaning period varies from once every six nths to once every two years. All cleaning of heat- hanger tubes can be accomplished mechanically, h a wire brush or rod. Where the amount of scale is excessive, chemical treatment can be used effec- ly, and also for cleaning out algae and manganese xide.

VANTAGES OF A RECIRCULATING COOLANT SYSTEM

The recirculating coolant circuit of a power rectifier sists essentially of the heat exchanger, water pump, ter storage tank, and the water jackets of the rectifier ks. The water jackets of the rectifier tanks, the heat hanger, storage tank and interconnecting piping of ny pumped rectifiers are made essentially of ferrous terial.

Both general corrosion and pitting corrosion were rcome by providing a circulating coolant consisting nhydrous sodium chromate (Na_2CrO_4) and water.(4) e sodium-chromate-treated coolant protects iron faces from corrosion by providing a protective film. e effectiveness of the protective film appears to be not only to the simple production of a film of iron de but also to the inclusion of chromic oxide in the cipitate or rust formed in the corrosion reaction. is so modifies the surface that a *dense and adherent tective film* results rather than loose nonprotective t or pit. Likewise the sodium chromate solution pro- ts against galvanic corrosion, which occurs between e joints of copper and iron. Galvanic corrosion is a quent cause of trouble especially when the potential erence is increased by the performance of an elec- machine.

E CORROSION INHIBITING COOLANT

As an example of the effectiveness of a sodium- omate-treated coolant, FIG. 4 shows three iron ctrodes, all immersed in their respective containers twelve days. The electrodes immersed in separate tainers were: *A*, the positive electrode of a cell con- ning a tap water; *B*, the positive electrode of a cell taining a one-half per cent solution of sodium omate, using the same source of tap water. A five- t potential was impressed between the electrodes of se two cells. Electrode *C* was placed in a container of same tap water, with no potential impressed. Elec- de *C* is an example of the so-called general corrosion, irly uniform covering of reddish brown iron oxide. tubercles or concentrated corrosion is noted on this cimen. Electrode *A* shows the effect of electrolytic disintegration, much of the iron having been removed by the effect of the few milliamperes of current. As a contrast, electrode *B*, which was immersed in a sodium chromate solution, shows on microscopic examination no evidence of either the so-called general or concentrated form of electrolytic corrosion. It is interesting to note that by virtue of the relatively high electrical conductivity of the sodium chromate solution, approximately ten times as much current was passed between the electrodes of this cell in comparison with electrodes of the cell containing tap water and electrode *A*. Subsequent tests where the cell current was increased several hundred percent, indicated that even with this unusual current, the one-half percent solution of sodium chromate was capable of inhibiting electrolytic corrosion.

The corrosion inhibiting coolant for the recirculating system contains a quantity of anhydrous sodium chromate, sufficient to make a one-tenth percent solution in distilled water. When tap water having a high degree of purity is available, a coolant can be made by using a sufficient amount of anhydrous sodium chromate to make a one-half per cent solution.

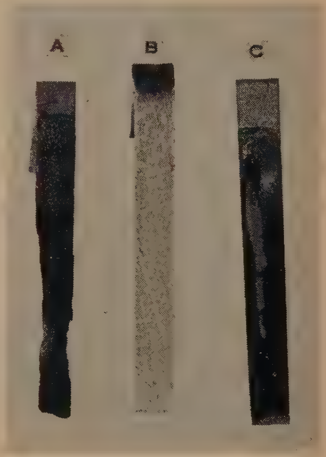


Fig. 4. Iron electrodes used in corrosion test

A: Positive electrode in tap water at 5 volts
B: Positive electrode in sodium-chromate-treated tap water at 5 volts
C: Electrode in tap water, no potential

Periodically, it is necessary to add water to the system to replace that which has evaporated; also tests must be made to check the effectiveness of the coolant in resisting corrosion. The effectiveness test is made by electrochemical means, by placing a sample of the coolant in a test tube containing two iron wire electrodes. A potential of 5 volts is applied to the electrodes and the electrochemical action observed. The occurrence of corrosion on the positive electrode indicates that more sodium chromate should be added to the coolant. A further test, to determine whether an excessive amount of sodium chromate has been added, is made by measuring the electrical resistance of the coolant. Table II indicates proper resistivity limits for various coolants taken at a temperature of 25 C.

SPECIAL HEAT EXCHANGERS

Installations located in close proximity to an ocean may utilize sea water as a tap water coolant. If the water is pumped from an ocean bay or harbor, then a

(Continued on following page)

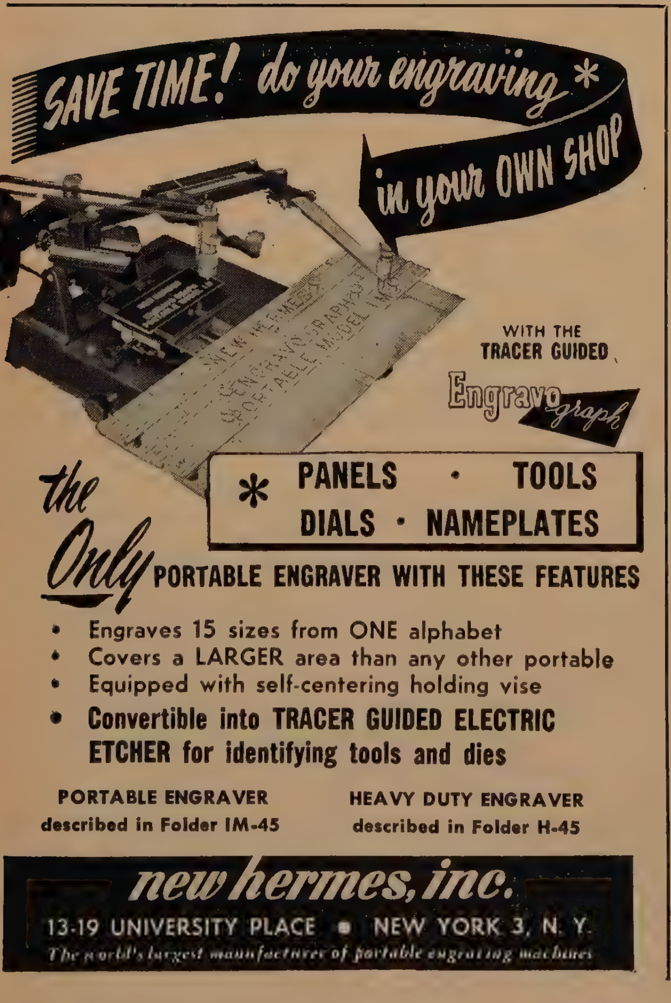
(Continued from preceding page)

so called brackish water is obtained. The brackish water is usually more corrosive in nature than sea water, because of the great amount of organic matter present in addition to the high chloride content obtained from its mixture with sea water. For this reason, parts of heat exchangers conducting waters of this nature are constructed of metals such as silicon bronze, cast bronze, cast iron, or admiralty metal.

As a replacement item, cast iron parts are preferable to ordinary iron parts. Both cast iron and ordinary iron corrode in sea water; the cast iron corrodes uniformly across its surface, and ordinary iron in what is known as pit corrosion. For this reason, the service life of ordinary iron may be relatively short, while that of cast iron is many times greater and its replacement time is predictable.

TABLE II
RESISTIVITY LIMITS FOR TEST OF COOLANTS

Solution	Specific Resistance Ohm-centimeters
0.1% Na_2CrO_4 With Distilled Water	600–800
0.5% Na_2CRO_4 With Tap Water	150–200
Tap Water	2,500 Approx.
Steam Condensate	30,000 Approx.
Distilled Water	200,000 Approx.



SAVE TIME! do your engraving * in your OWN SHOP

WITH THE TRACER GUIDED Engravograph

the Only PORTABLE ENGRAVER WITH THESE FEATURES

* PANELS · TOOLS
DIALS · NAMEPLATES

- Engraves 15 sizes from ONE alphabet
- Covers a LARGER area than any other portable
- Equipped with self-centering holding vise
- **Convertible into TRACER GUIDED ELECTRIC ETCHER for identifying tools and dies**

PORTABLE ENGRAVER described in Folder IM-45

HEAVY DUTY ENGRAVER described in Folder H-45

new hermes, inc.
13-19 UNIVERSITY PLACE • NEW YORK 3, N. Y.
The world's largest manufacturer of portable engraving machines

ELECTROLYTIC LEAKAGE CURRENT

Depending on the rectifier application, the potenti difference between the ends of the insulating coolan conductors may be 250, 600, 1500, 3000 volts or mor The length of the insulating coolant conductor is d termined from the amount of leakage current permitte through the coolant and the resistivity of the coolan During rectifier operation, the insulating coolant co ductors containing tap water form an electrolytic cel The potential difference across the ends of the insula ing tubing is such that the end at rectifier potenti will become electrolytically disintegrated, and in tim will result in perforation of the pipe connection. Prob lems of this nature have been eliminated by insertin a metal rod part-way into the insulating coolant co ductor and at rectifier potential (FIG. 5). This metalli

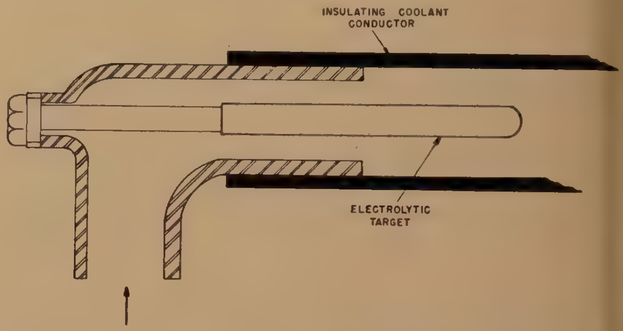


Fig. 5. Electrolytic target installed in pipe of cooling system

rod or electrolytic target⁽⁵⁾ will pick stray currents fro the coolant and thus prevent the disintegration of th coolant pipe of rectifier potential. Depending on th type of coolant and the degree of protection desire electrolytic targets of iron, stainless steel, copper, an platinum have been successfully applied.

In rectifier installations where the double-way elec trical connection is used, the water jackets of the var ous rectifier tanks or tubes perform at different elec trical potentials. Satisfactory corrosion protection obtained in such systems by providing ample lengths coolant conductors and applying electrolytic target where necessary.

SUMMARY

The facts accumulated during twenty years of co rosion control indicate that where a coolant circuit necessary for an essentially iron system the applicatio of anhydrous sodium chromate provides a positive an economical means of preventing a corrosion problem.

REFERENCES

(1)"Performance of Pumped Ignitron Rectifiers," by C. Herskind and E. J. Remscheid, *AIEE Transactions*, vol. 67, 194 pp. 215-218.

(2)"Power Rectifiers," by Emil J. Remscheid, GENERAL ELE TRIC REVIEW, vol 47, March 1944, p. 25.

(3)U. R. Evans: *Metallic Corrosion, Passivity, and Protectio* E. Arnold, London, First Edition, 1937, p. 340.

(4)"The Water-cooled Steel-tank Rectifier Corrosion Problem by E. J. Remscheid, *AIEE Transactions*, vol. 60, April 1941, p 176–177.

(5)"Protecting Cooling Systems Subject to Electrolysis," Dr. E. W. Balis and Dr. H. A. Liebhafsky, GENERAL ELECTR REVIEW, vol. 51, September 1948, p. 40.

HIGH LIGHTS AND SIDE LIGHTS

New Industrial Use of Co-ordinated Control

the first installation of its kind, lidyne and electronic control will be used to provide a completely co- hated drive on a veneer lathe, pres- roll, tipple, and trays for a western ood factory.

operation, a thin sheet of veneer is ed from the full length of the log placed een two chuck centers. The knife is nced at a specified rate so as to pro- a continuous sheet of veneer of orm thickness. The sheet is in turn ed up by the tipple, which feeds the er to the selected storage trays. These are actually conveyors arranged in ck, one above the other.

he veneer lathe drive is a direct-current m utilizing amplidyne control to in the maximum performance from drive components. The key to the is the use of an amplidyne exciter. appearance and maintenance, the lidyne resembles a conventional direct- ent exciter; however, where the ratio ower output to excitation power for nventional exciter may be 25:1, the ratio is 1000:1 for the amplidyne. means that the veneer lathe drive is rolled by currents amounting to a ion of an ampere.

he drive is designed to hold constant er-cutting speed as the log diameter nges. The unique combination of a or-mounted tachometer generator and -operated rheostat produces a volt- directly proportional to veneer sheet d. This voltage is balanced against a voltage, and any difference is im- sed across an amplidyne control field. an infinitesimal amount of ampli- excitation controls the amplidyne ut, the small voltage difference con- the speed of the driving motor.

he co-ordinated drive also includes a hp motor to drive the tipple conveyor, a 15-hp motor to drive the storage trays. trol is arranged so that the speed of the e and tray conveyors will be equal to, will follow, linear sheet speed of the ed veneer as it comes from the lathe. 3-hp pressure-roll Thy-mo-trol drive ing used for the first time to maintain tant torque on the roll above the . Standard wound-rotor motors with ercent fixed secondary resistance are nonly used for this application. It pected that the new constant-torque will improve the quality of veneer the performance of the equipment.

master speed-control lever is pro- d for the lathe operator. The speed e entire system is controlled by this , and all drives will stop when the rol is in the OFF position.

More Motors on the Farm

Progressive farms are continuing to turn to electric power in an effort to do chores more rapidly and more efficiently.

On a poultry farm in Ohio, a belt-and-bucket elevator powered by three fractional-horsepower motors is the central link in a modern feeding system. Standing 28 ft high and extending into an aperture especially prepared in the barn, the grain elevator handles a capacity of 200 bushels of grain per hour. The owner estimates that it will carry about 14,000 bushels of grain this year.

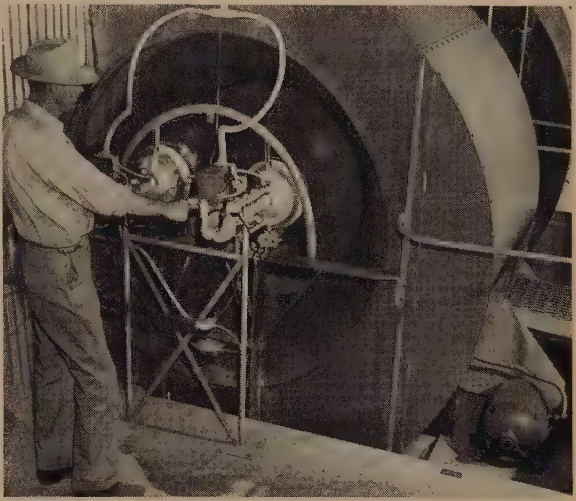
The elevator carries grain from the sheller to the grinder and elevates ground grain to the feeder mixer. From the mixer, the feed is carried automatically to the poultry houses. The addition of a second outlet valve simplifies truck loading. The grain is lifted by the elevator and in the same operation is poured through the flexible pipe outlet into the truck.

Providing the daily feed supply for 18,000 lambs and cattle becomes a routine chore on a California cattle and sheep farm where a 60-hp electrically driven feed mill is in continuous operation from eight to twelve hours daily. During the winter season, when the 640-acre farm is up to full capacity, 15,000 lambs and 3000 cattle consume nearly 22 tons of mixed grain and hay feed.

After grinding, the feed is blown through a pipe up to the second-story level of the barn. It is then moved by a conveyor belt to a feed truck, which delivers it to chutes running directly to the troughs. Mechanical handling not only eliminates waste of loose hay and whole grain, but also makes it possible to feed a large number of livestock in a relatively small area in a short time.

Green rice is being dried and stored at the rate of 1000 bushels an hour at a recently completed grain drying plant in California. With a capacity of 313,600 bushels of green rice, the plant utilizes 21 motors of varying sizes to power the conveyors, fans, elevators, and other grain-handling equipment.

When a truckload of green rice is received at the plant, a hydraulic dumping truck-scale weighs, tilts, and dumps the load into the receiving hopper at the rate of three minutes per truck. The green grain is moved by a screw conveyor from hopper to receiving bins, and then into the drier. After chaff removal and drying, the rice is stored in elevators for shipment to the mill.



Adjusting jet of the flame drawn into the drier by 10-ft fans. Part of the operation of high-speed rice drying and storing

In addition to large-scale rice-drying operations, individual farmers are drying other grains, fruits and nuts with smaller, portable electrical units.

Bus Gates Operate Automatically with Aid of New Spotlights

Five high-powered spotlights, with allied electrical equipment, are helping to relieve the manpower shortage by releasing three gate operators for other duties at a Detroit bus terminal. The lights are employed in the operation of electric-eye units which control the opening and closing of two gates through which buses enter and leave the downtown depot. The installation eliminates the need for gate men to raise and lower the gates manually.

To fill the requirement for a powerful but concentrated light source for exciting photoelectric cells, engineers decided upon the new 300-watt narrow-beam spot lamp, of the all-glass sealed-beam type, which has a beam of 100,000 candlepower, about three times that of the auto head-lamp.

Side brightness was reduced by the use of aluminum shields with a restricting orifice 2⅜ inches in diameter around the

(Concluded on following page)

face of the lamps. The result is a sharply defined beam which is not obnoxious to the eye, yet has enough effect too perate photoelectric cells desensitized to the point where they will not operate from reflected sunlight or other external light sources.

The installation is expected to pay for itself within nine months because it releases three gate operators urgently needed for other duties.

Science Fellowships for High School Teachers

The seventh annual General Electric Science Fellowships for high school and preparatory school teachers, designed to give the participants a closer understanding of scientific principles as applied to industry, will be awarded in 1951 for study at Union College, Schenectady (N.Y.), and Case Institute of Technology, Cleveland (Ohio). The program is conducted by the faculties of the two colleges in co-operation with scientists and engineers of the General Electric Company.

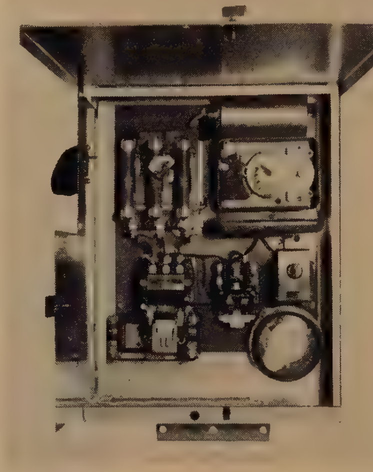
Fellowships at Union College, applicable in the fields of chemistry and physics, will be awarded for a program of summer courses from July 1 through August 10, to fifty teachers from the New England states, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, and the District of Columbia. Fifty fellowships for the Case Institute program, to be conducted from June 25 through August 3, will be awarded to physics teachers only, from Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, Western Pennsylvania, Tennessee, West Virginia, and Wisconsin.

Besides living on or near the two campuses during the program and receiving their basic instruction in the classrooms and laboratories there, the fellows will visit General Electric plants and laboratories and other outstanding research laboratories nearby for demonstrations of practical applications of the work they are doing.

The grant for each fellowship by the General Electric Company includes tuition, fees, maintenance at the college during the six weeks, and traveling expenses. Applications will be considered only from experienced secondary teachers holding at least a bachelor's degree representing substantial undergraduate courses in chemistry or physics and in mathematics. Completed applications for the Schenectady program must be received by April 1 by the Committee on General Electric Fellowships, Union College, Schenectady 8, N. Y., to which inquiries and requests for application forms may be addressed. Information on the Cleveland fellowships may be obtained from Dr. Elmer Hutchisson, Dean, Case Institute of Technology, Cleveland 6, Ohio. Final applications to the latter program must be returned by April 14.

New Pumping Control for Oil Wells

New design in the magnetic starter, overload relay, motor disconnect switch, and lightning arrester characterize an oil-well pumping control that has been developed. In addition to the four new design components, a new starting timer provides increased flexibility for starting motors after shutdown, and an improved time switch has new camriders for more reliable time settings.



Newly designed oil-well pumping control, with front cover, door, and timer open

By far the outstanding feature of the new pumping control is its ability to withstand voltage surges of 22-kv crest with a 1.5 × 40 wave and a 10-amp current crest. These values, based on data collected from all over the country, cover 90 percent of the probable lightning conditions. In all tests after repeated surges, the starter operated without failure.

The magnetic starter is a three-pole lift type equipped with a strongbox magnet coil for protection from dust and dirt. Clamp-type solderless terminals and solid silver contacts are utilized throughout the component. A bimetal isothermic overload relay has been specially designed with a renewable interchangeable heater, hand or automatic reset, and large solderless terminals.

A three-pole fusible disconnecting switch, any pole of which can be removed for repair and inspection, affords quick make-or-break mechanism. An ON-OFF indication stamped on the switch base indicates the position of the switch when the case is open. An entirely new Thyrite type lightning arrester, metal-enclosed, protects the timing relays and the contactors. A weather-resisting sheet-steel enclosure, housing all the parts of the control with drip shield, is finished with a special aluminum paint to resist corrosion.

Annealing Furnaces for Produ Quality and Economy

Grain size of copper tube has be
controlled by one manufacturer to
remarkably close tolerance of ±0
millimeters since the installation of an
electric-heated annealing furnace. T
even distribution of electrical heat,
gether with the exact control of time a
temperature, assures a uniform anneal
seamless copper tube.

The roller-hearth furnace has a ma
mum operating temperature of 1600
Over-all length is 73 ft, and the insi
wall-to-wall width is 5 ft. The furna
sections are composed of a charging ves
bule, heating chamber, cooling zone, a
a discharging vestibule.

The cooling zone is equipped throug
out its entire length with a water jack
The continuous movement of wo
through the furnace is accomplished
eighty driven rollers spaced on 12-
centers. Controlled atmosphere is ge
erated by two units, one operating at 40
cu ft per hour, the second at 2500.

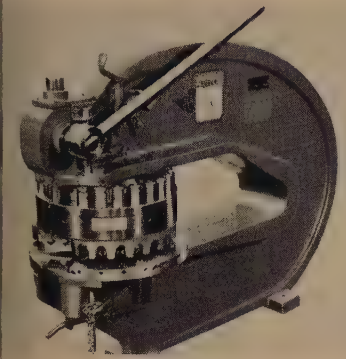
The furnace has demonstrated unusu
flexibility on many occasions. On ve
quick notice the operator can change fro
annealing 30-ft lengths to small-diame
coils, or from short straight lengths
large-diameter coils. The furnace h
handled 3000 lb of copper tube per ho
the limit set by the difficulties attenda
on handling small-diameter tube rath
than by the actual capacity of the furna
itself.

In another installation, substant
savings have been achieved by a larg
scale manufacturer of malleable castin
for the railroad and automotive indu
tries through the use of five anneali
furnaces: three high-temperature fu
naces maintaining a temperature of 18
F; and two low-temperature drawing fu
naces with a maximum operating te
perature of 1300 F.

The five electrical control systems ha
been designed for special application
the malleable-casting industry, and ea
can be shut off independently by a mas
switch without affecting the other fu
naces in the bank. Separate controls reg
late and keep constant the heat on t
side of each furnace; an identical cont
equally regulates roof heat. Thus unifo
heat is assured throughout the furna
and a high quality of annealing results.

In addition to a reduced producti
time cycle and higher quality, oth
economies and advantages have be
realized from this change to electric he
the high expense involved in the use
annealing containers has been limite
better working conditions and substant
savings in floor space have result
replacement of heating units and oth
maintenance expenses have been reduc
to an estimated 40 percent below those
fuel-fired furnaces.

NEW PRODUCTS: AND WHAT THEIR MAKERS HAVE TO SAY ABOUT THEM



Punch Press

Plug-in Unit

Prong Dies

Prong Dies

line of small prong dies for producing
orm and smooth precision threads. The
are made with 36 to 360 threads per
in diameters from 0.250 in. to 0.016 in.
erances can be held to ±0.0002 in. on
pitch diameter. All threads are ac-
tely hobbed and lapped to produce
p cutting edges and smooth threads.
terial is either high-speed carbon or
ial alloy steel to meet job requirements.
oodruff & Stokes Co., Quincy 69, Mass.

Coating Intermediate

baking-type coating intermediate,
08, combining outstanding chemical
tance with flexibility and heat resist-
. Protective coatings formulated with
chemical intermediate possess the char-
ristics of the intermediate which include
tance to alkalies, acids, oxidizing agents,
ents, sales, etc. over a wide temperature
e; extreme toughness, flexibility, and
tance to abrasion; and unusual stability
ging at elevated temperatures. Coatings
ulated with the intermediate can be
ented in a wide variety of colors.—*Gen-*
Electric Co., Chemical Dept., Pittsfield,
s.

Punch Press

Model 18B punch press designed to handle sheet material up to 48 in. wide. A rotary turret permits the operator to locate any one of 18 desired punch sizes almost instantly. The turret rotates to the selected punch size, and locks into position automatically. The press operates efficiently on cardboard, fiberboard, plastic, or sheet iron up to 10-gage thickness. Since dies and punches are accurately prealigned, the press assures a mechanically precise job without manual adjustments.—*Rotex Punch Co., 4726 E. 12th St., Oakland, California.*

Plug-in Unit

Any three or four terminal network can now be made into a convenient plug-in unit by using a Model 19-G Labcase. Experimenters, engineers, researchers, and others will find them advantageous for housing wave filters, wave shaping circuits, and other special or standard circuits. The resulting plug-in units can easily be added to or removed from an experimental set-up for comparison purposes. Since the input terminals of one can be plugged into the output terminals of another, any number of similar or different units can be obtained in tandem arrangements.—*Berkshire Laboratories, 526 Lexington Rd., Concord, Mass.*

Attenuator

A new miniature-size T network attenuator, series 730, having 30 steps of attenuation in only 2¼ in. diam. Insertion loss is zero; input and output impedance constant. The unit comes in steps of 0.5, 1.0, 1.5, or 2.0 db. It has a flat frequency characteristic to 30 kc which can be extended to 200 kc for special requirements. Its standard resistance accuracy is ±5 percent. Some of its features include: knee-action switch rotor; silver-alloy contacts; Oilite bearings; two-piece dust cover; and short rotor arms. —*Daven Co., 191 Central Ave., Newark 4, N. J.*

Extrusion Takeup

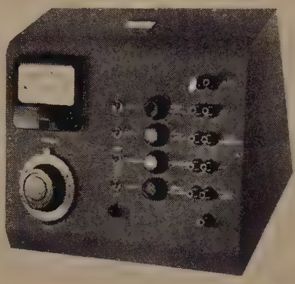
A high-speed constant-tension dual-reel continuous extrusion takeup unit with integral capstan and tension stand for plastic or rubber coated wire, cord, or cable. Speed range is from standstill to more than 2600 fpm, with instantaneous acceleration of the empty reel to synchronous wire speed as soon as crossover is made. No interruptions or slowdown in the winding process is necessary to shift from full to empty reel. All drives are hydraulic and self-contained with fully enclosed oil-immersed gears.—*Industrial Ovens, Inc., 13825 Triskett Rd., Cleveland 11, Ohio.*

Electronic Timer

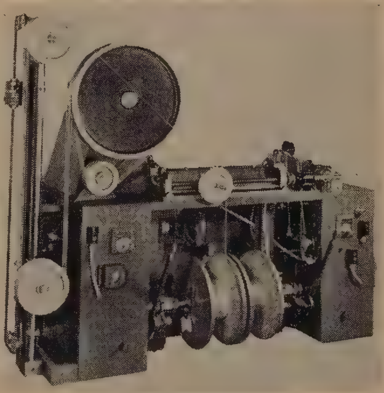
Model CK electronic timer using cold-cathode trigger tube. Since the tube requires no filament current, there is no wear on the tube during standby periods, and timing is instant and accurate without warm-up. Also, one can recycle the timer immediately, and it is not necessary to recharge the timing condenser between cycles. Four time ranges are: 1.5, 3, 6, or 12 sec; a dial with 100 graduations allows the timer to be set for any desired percentage of the total range. —*Farmer Electric Co., 21 Mossfield Rd., Waban 68, Mass.*

Dynamic Analyzer

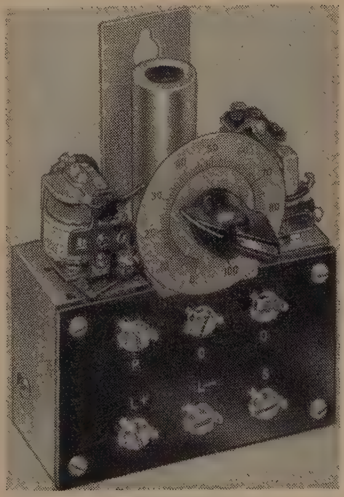
The 100-A analyzer is an instrument that facilitates the measurement of frequency and transient response of low-frequency systems by electrical methods. It is particularly applicable to servomechanism, either as a closed loop, or in its individual components. It functions by providing periodic perturbation signals to be injected into the error or input channels of the device under test, together with sweep and comparison voltages with which to view the output member excursion on the cathode-ray oscilloscope. These wave shapes are generated by electromechanical elements geared together and driven by a precision speed control. The flexibility of this device assures universality of its use.—*Industrial Control Co., 1462 Undercliff Ave., New York 52, N. Y.*



Dynamic Analyzer



Extrusion Takeup



Electronic Timer

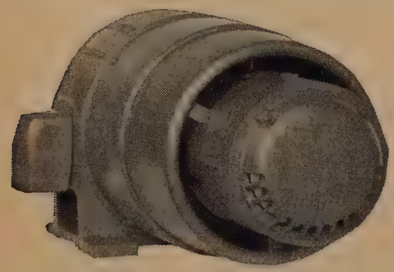
Pulse Transformers

ERA pulse transformers designed especially for circuits requiring low-power applications. General applications include triggering and counting circuits and blocking oscillators. More specific uses are for d-c isolation, inversion, pulse shaping, and pulse-transmission circuits. Cases are made of molded mica-filled thermosetting plastic.

Mounted with 6-32 screws.—*Engineering Research Associates, Inc., 1902 West Minnehaha Ave., St. Paul W4, Minnesota.*

High-speed Generators

The line of Tri-Clad* high-speed synchronous generators now extends down through 1.875 kva. Machines added to the line are available in four basic designs in ratings of 1.875 to 50 kva, 60 and 400 cycles. The 60-cycle generators in three standard types provide a range of characteristics for various categories of voltage regulation and motor-starting requirements. The basic 60-cycle unit is an externally regulated generator designed to operate with standard voltage regulator in the exciter field circuit. One modification provides self-regulated features for applications where average voltage regulation and motor-starting ability is desired; another utilizes the basic 60-cycle generator, a special overhung amplidyne exciter, and a static voltage regulator. Taps are provided for adjustment to +5 percent, zero, or −5 percent variation from rated voltage. The high-frequency 14-pole synchronous generator is suitable for applications requiring 400-cycle power. The units are also applicable in frequency-changer equipments driven by 3500-rpm motors.—*General Electric Co., Apparatus Dept., Schenectady 5, N. Y.*



*Reg. Trade-mark G.E. Co.

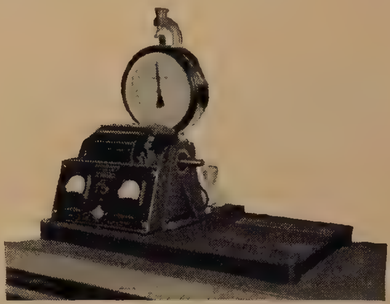
Degasifier and Pump

A completely automatic self-contained pumping system for pipe-type cable which maintains correct pressure within the cable. Designed for extra-high-voltage power-transmission systems requiring pipe-type oil-filled cable, it provides a means to introduce degasified and dehydrated oil into the cable without exposure to the atmosphere.

The controls, indicators, and warning signals of the unit can be duplicated on a panel board in a remote location if desired. They provide visual and audible warning signals for power failure, high or low oil level in the reservoir, high or low nitrogen pressure in the oil reservoir, high or low pressure in the cable, excessive pumping time, excessively high or low room temperature in the pump house, and for fire.—*Filtration Division, Bowser, Inc., Fort Wayne, Indiana.*

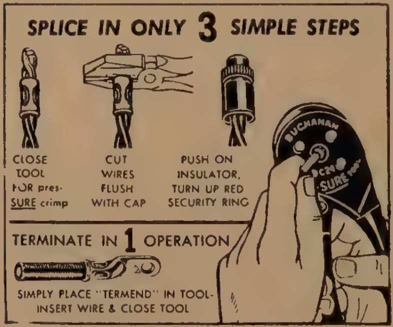
Dynamometer

An improved design of fractional-horsepower dynamometer set for small-machine and appliance manufacturers. The instrument aids in analyzing and demonstrating the operation of fractional-horsepower motors, generators, and dynamometers as well as the testing of internal-combustion engines and mechanical equipment of similar rating. A control panel contains instruments for reading field voltage and armature current, a field control rheostat, and a 3-way switch for selecting desired resistance loads. A preloaded scale permits direct readings with the unit operating as a motor or generator. Optional tachometer equipment can be used because of the double shaft extension. The equipment has a continuous absorption or motoring rating of ¾ hp at 2000 rpm. Maximum permissible safe speed is 4000 rpm.—*Special Products Division, General Electric Co., Schenectady 5, New York.*



Connectors

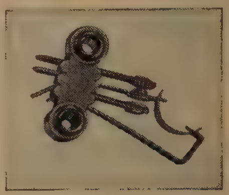
A line of splice caps with improved open-end construction for "pigtail" splicing of electrical wires. With these caps installation and inspection is facilitated, and cap flush with wire insulation for circuit protection and full-depth insertion of wire for joint efficiency is assured. Only two sizes of caps are required for the most frequently used combinations of two or more wires ranging from two No. 18 to three No. 8. Quickly applied snap-on insulators of fixed insulating value eliminate necessity for taping of joints preventing insulation breakdown in service.—*Buchanan Electrical Products Corp., 1290 Central Ave., Hillside, New Jersey.*


SPLICE IN ONLY 3 SIMPLE STEPS
CLOSE TOOL FOR pres-SURE crimp
CUT WIRES FLUSH WITH CAP
PUSH ON INSULATOR, TURN UP RED SECURITY RING
BUCHANAN
SURE TOOL
TERMINATE IN 1 OPERATION
SIMPLY PLACE "TERMEND" IN TOOL-
INSERT WIRE & CLOSE TOOL

Chemical Compound

D-Scale-RW compound for descaling or derusting iron or steel parts in tumbling barrels. An inhibited acid-type powder with wetting agent added, it is used at concentrations of 4 to 16 oz per gallon of water depending on the amount of scale. Tests disclose that it can remove most scale in 15 to 30 min. It can be used either where pa are self-tumbled or with abrasive mediu it is safe to handle and does not throw fumes, to cause rusting of equipment parts in room where used; and it remov scale completely.—*Magnus Chemical C Inc., Dept. GER, Garwood, New Jersey.*

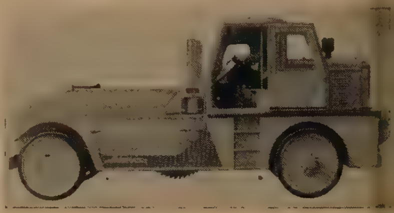
Switch



A midget snap-action switch for co densed timing and sequence operatio This open-blade switch utilizes the Ac rolling-spring principle. Contact arms a blades are held between molded nylon melamine side members secured by eyel capable of taking a No. 1 mounting scre Contact points are made of silver. Curren carrying capacity is 3 amp, 125 volts, a —*Acro Switch Division, Acro Manufacturi Co., Columbus 16, Ohio.*

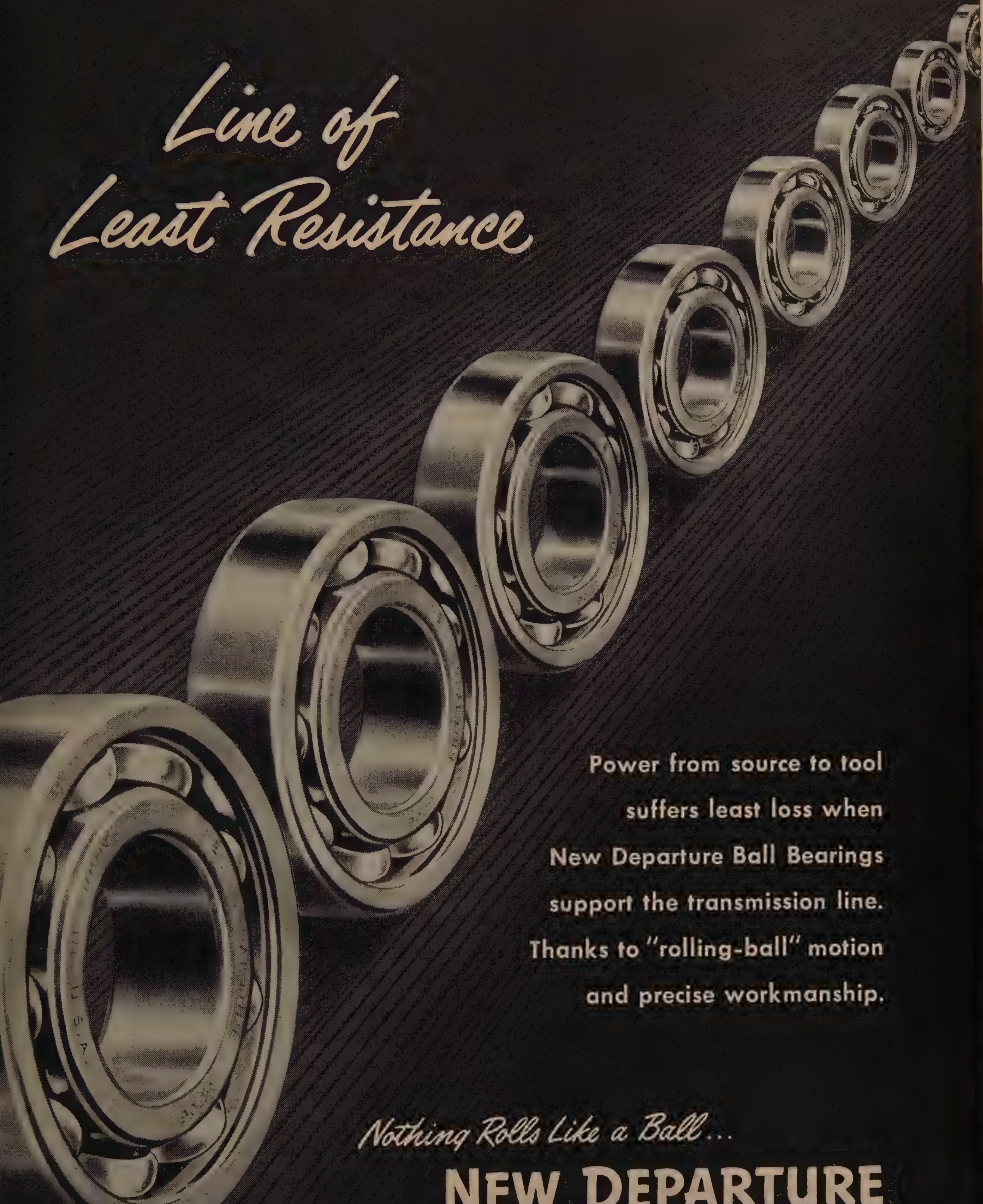
Pavement Cutter

A pavement cutter designed to reduce a minimum the inconvenience caused necessary street openings for the repair water mains or underground utility lin Two large wheels, carrying tungsten-ca bide-tipped bits, saw parallel 2-in. slots the pavement, 18 in. to 54 in. apart. T strip of paving between the slots can then removed in chunks. Tests indicate that t cutter is a time saver, tripling the speed removal thereby reducing the cost. The ton machine is mounted on four solid rubb tires and is powered by a 75-hp gasoli engine. It travels from job to job at a spe of about 12 miles per hour in direct ge drive. Hydraulic drive is used to feed t machine while cutting.—*Joy Manufacturi Co., Henry W. Oliver Bldg., Pittsburgh Pa.*



Magnetic-particle Clutch

A new magnetic-particle clutch, call the Magneclutch, to be used by indust for control of torque, speed, and positi The clutch is a controllable coupling wh utilizes the linking action of a dry magne mixture in a magnetic field between driv and driven parts to transmit torque. T magnetic field is established by curr flowing through a coil and, by varying current, the degree of clutching can be c trolled. Design and operating advanta include: small control power with ra response; no wear on torque transmitt surfaces; torque at zero slip; large ma mum-to-minimum torque ratio; and e adaptation to remote control.—*Vick Electric Division, Vickers, Inc., 1815 Loc St., St. Louis, Mo.*



Line of Least Resistance

Power from source to tool suffers least loss when New Departure Ball Bearings support the transmission line. Thanks to "rolling-ball" motion and precise workmanship.

Nothing Rolls Like a Ball...

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE · DIVISION OF GENERAL MOTORS · BRISTOL, CONNECTICUT

125

TRADE LITERATURE

BENDING MACHINES—Thoroughly covers the subject of bending metals, showing on 18 pages step-by-step methods of how the various bends are formed by Di-Acro precision bending machines. A full page is given to each type of bend. Thirty-six pages. Titled "It's Easy to Bend."—*O'Neil-Irwin Manufacturing Co., Lake City, Minnesota.*

DEMINERALIZER—A folio of catalog sheets each containing a photographic illustration, a working diagram, a complete description of parts, and both a specifications and a performance chart of a particular type of industrial water demineralizer. Eight sheets. —*Penfield Manufacturing Co., Inc., 19 High School Ave., Meriden, Conn.*

FEED WATER CONTROL—A straightforward, concise analysis of problems encountered in feed water control explaining how the air-operated three-element system helps solve them. Liberal use of diagrams, cutaway views, chart records, and photographs of modern installations. Sixteen pages. Bulletin 105-C.—*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*

GROUND TESTERS—A bulletin on Megger ground-testing instruments for measuring resistance of earth to ground connections and for measuring earth resistivity. Aids to proper selection, application, typical tests, drawings, and illustrations all help to make this a valuable publication for those engaged in related problems.—Twenty pages. Bulletin 25.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Penna.*

HOLE-PUNCHING SYSTEM—Describes a multiple hole-punching system designed to speed up production from drawing board to completed part. Largely pictorial. Eight pages. Brochure M.—*Wales-Strippit Corp., North Tonawanda, N. Y.*

INSULATORS—A bulletin titled "Internal Insulators for Electronic Tubes" considers requirements of vacuum-tube insulators and outlines facts about various technical ceramics especially adapted to those requirements. For the first time characteristics of AlSiMag 548 are published. Four pages. Bulletin 502.—*American Lava Corp., Chattanooga 5, Tennessee.*

INSULATING OILS REGENERATION—Subjects include contamination and its effects; moisture and sludge; heating of insulating oil; blotter presses, filters, and centrifuges; and effective ratings. Line drawings and photographs supplement the text. Four pages. Bulletin No. 50-DO.—*Sharples Corp., 2300 Westmoreland St., Philadelphia, Penna.*

LIGHTING—A booklet titled "See Your Home in a New Light" containing an artist's conception of the application of 22 recipes for better living in a better-lighted home. The contents help to provide the public with authoritative information and guidance on what lighting equipment to use, and where to place it, for each home-seeing task. Thirty-two pages.—*Lamp Department, General Electric Company, Nela Park, Cleveland 12, Ohio.*

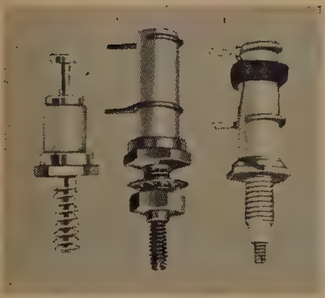
PHONO ACCESSORIES—A phono access
catalog with descriptions and data
variable reluctance cartridges, replacem
baton styli, tone arms, and phono
amplifiers. Sixteen pages. *Receiver Divisi*
Electronics Department, General Electric
Syracuse, N. Y.

SILVER-ALLOY BRAZING—Full of facts
data pertaining to silver-alloy brazing w
Easy-Flo and Sil-Fos. Tells where and h
to use these alloys to the best advanta
shows many interesting applications,
scribes fast brazing techniques, and expla
how to speed up production and save ti
Twenty-eight pages. Bulletin 20.—*Handy*
Harman, 82 Fulton St., New York 7, N.

VIBRATING SCREENS—Concentric-action
brating screens for medium- and heavy-d
service, accurate sizing, thorough rinsi
and rapid dewatering of a wide range
materials from ashes to zinc ore are ill
trated, described, and tabulated. Twe
pages Book No. 2354—*Link-Belt Co.,*
N. Michigan Ave., Chicago 1, Illinois.

WIRING—A comprehensive manual
remote-control wiring prepared for arc
tects, engineers, and electrical contract
giving a detailed technical description
this new low-voltage system. Illustrates
features of the system, tells where it can
used, and explains the components t
make up the system. Thirty-six pag
Publication No. 16-200.—*Construction*
terials Department, General Electric Co
pany, Bridgeport 2, Conn.

SPECIALISTS IN GOVERNMENT "SPECS"—
Offer Help to Manufacturers

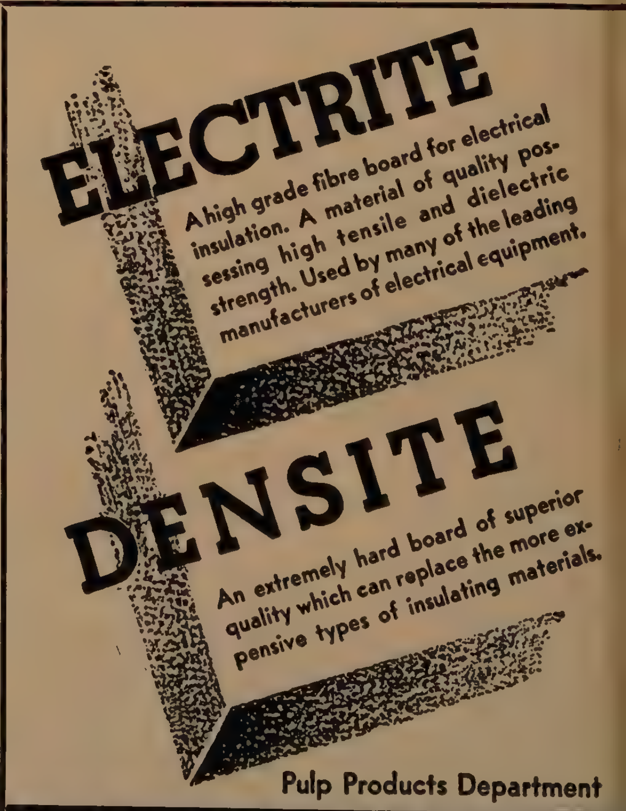


Long experience with the ever-increasing, constantly changing government specifications for electrical and electronic components has gained the Cambridge Thermionic Corporation wide acceptance as a supplier to manufacturers working on U. S. contracts — especially for the armed forces. With facilities for furnishing components in production quantities C.T.C. meets the most exacting government standards for materials, tolerances, finishes, moisture prevention, anti-fungus treatment and similar requirements.

Terminal board assemblies, plain and insulated terminals, coil assemblies, coil forms, hardware and other components are furnished guaranteed to meet government specifications.

C.T.C. also invites inquiries concerning its engineering service — a staff of experts available for consultation on your component problems. This service is without charge.

CAMBRIDGE THERMIONIC CORP.
462 Concord Ave., Cambridge 38, Mass.



ELECTRITE
A high grade fibre board for electrical insulation. A material of quality possessing high tensile and dielectric strength. Used by many of the leading manufacturers of electrical equipment.

DENSITE
An extremely hard board of superior quality which can replace the more expensive types of insulating materials.

Pulp Products Department

WEST VIRGINIA PULP & PAPER COMPANY
230 Park Avenue, New York, N.Y. 35 E. Wacker Drive, Chicago, Ill.

BOOK REVIEWS

(Available books may be purchased through the GENERAL ELECTRIC REVIEW *for domestic delivery; none sent on approval.)*

UIT ANALYSIS OF A-C POWER SYSTEMS:
II

n Clarke—John Wiley & Sons, New
. 1950. 396 pp. $8.50.

ss Clarke's two volumes constitute a
complete and authoritative treatise on
pplication of symmetrical components
ower systems under normal and ab-
al conditions. Written in easily under-
dable style, and directed to the im-
ate needs of the practicing engineer,
books present the necessary circuit
epts, formulas, equivalent circuits,
ts, and data for the steady-state
ysis of a-c power systems in both bal-
d and unbalanced states.

lume II stands on its own feet, and
be understood readily by anyone fami-
with symmetrical components. To this
the first chapter provides a brief sum-
y and recapitulation of the pertinent
ulas. Furthermore, the separate chap-
of the book are almost completely in-
ndent; the engineer need consult at
one time only that chapter dealing
his immediate problem. Each chapter
s a brief, but sufficient, review of under-
principles, and then develops the
ry to the extent necessary for practical
ications. Of particular interest are the
ussion in Chapters VII and VIII and
endix B on the two-reaction theory of
hronous machines, and the description
he steady-state and transient imped-
s and time constants of synchronous machines, as well as the appearance of harmonics under fault conditions.

This new book, together with Vol. I, should prove of inestimable value to power-system engineers.

L. V. BEWLEY

RECENT ADVANCES IN RADIO RECEIVERS

L. A. Moxon—Cambridge University Press, New York. 1950. 183 pp. $3.75.

This monograph gives a brief treatment of those principles and concepts of receiver design which are the result of advances made in the communications field in the last decade. The first half of the book deals with noise factor—its application to amplifiers and mixers, its measurement, and its minimization in receiver design. The remaining portion deals with the wide-band intermediate-frequency amplifier, varieties of receivers new to the communications field, and basic circuits which are common in radar, communication, and television receivers. The style is readable, and mathematics is restricted to those chapters which deal with receiver noise concepts.

R. A. MUSCHAMP

FRONTIERS IN COLLOID CHEMISTRY

Edited by R. E. Burk and Oliver Grummitt—Interscience Publishers, New York. 1950. 165 pp. $4.00.

This is the last volume (VIII) to be published in the "Frontiers in Chemistry" series. The editors have concluded, wisely enough, that with the increasing difficulty in obtaining outstanding speakers on the condition that their lectures be prepared for publication, it was more important to maintain the high quality of the lectures.

The present volume contains chapters on The Role of Absorption in Colloid Science, by Hugh S. Taylor; Frontiers in Chromatographic Absorption Analysis, by Harold H. Strain; Ion Exchange with Special Reference to Synthetic Resins, by Robert J. Myers; Sedimentation, by V. R. Damerell; and two chapters by James W. McBain: Colloidal Electrolytes, Wetting Agents, and Detergents; Organization of Crystals and Micelles of Soap, Solubilization, and Detergency.

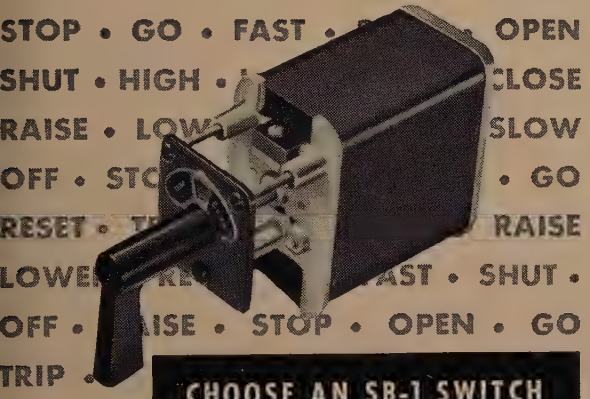
A. E. NEWKIRK

STEAM TURBINES AND THEIR CYCLES

J. Kenneth Salisbury—John Wiley & Sons, New York, 1950. xvi+645 pp. $9.00.

Mr. Salisbury's latest book provides the turbine designer with extensive design procedure for the thermodynamic analysis of the prime mover and its auxiliaries. Primarily, however, the text will serve as an excellent reference source for application and power-plant engineers and all men concerned with purchasing, installing, and operating steam turbines.

(Concluded on following page)



CHOOSE AN SB-1 SWITCH
FOR YOUR CONTROL JOBS

You can use this sturdy, versatile control and transfer switch on practically any circuit for practically any job—over 10,000 circuit-sequence combinations are possible. Rated up to 20 amperes at 600 volts a-c or d-c; and standards are ready on four weeks delivery. Easy to order, too. Mount on panels 1/8 to 2 inches thick. Switch shown is 8 1/4 inches overall, 2 3/4 inches wide, 4 1/4 inches high. See your G-E sales representative and write for bulletin GEA-4746. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC
856-21

IN ALL BRANCHES OF INDUSTRY

MORE ILSCO CONNECTORS are used in safety switch breakers, panel boards and many other electrical installations than all others combined.

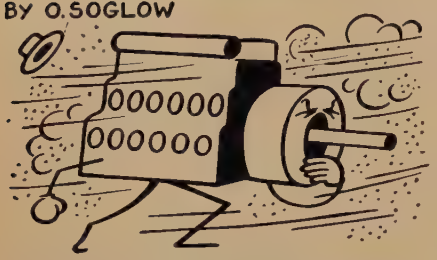
Write on your letterhead for your personal copy of 80-page ILSCO catalog.

5748 Mariemont Ave., Cinn. 27, Ohio

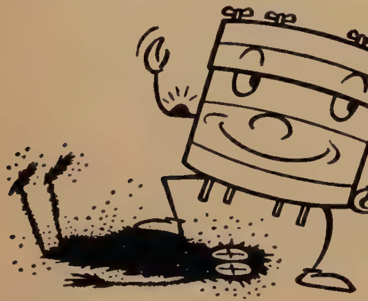
ILSCO COPPER TUBE & PRODUCTS, INC.

AIR-MAZING FACTS

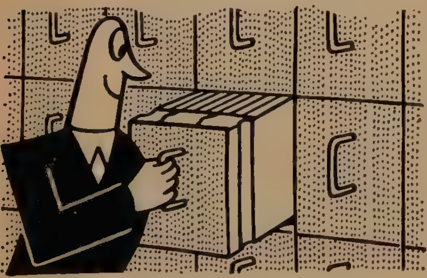
BY O. SOGLOW



DUST STORM THAT NEVER STOPS! Industrial engines live in a never-ending storm of dust, dirt and grit. While sucking in vast amounts of dirty air, a 1000 hp. engine with no intake protection would swallow more than 700 lbs. of dust every year.



DUST IS DONE FOR! Leading engine makers beat the dust hazard by using Air-Maze oil bath filters to provide clean intake air. Air-Maze oil bath filters "scrub" the air in oil, stop abrasive dust before it can damage polished engine parts.



FILTERS—NOT FILES! Electromaze electronic air filters remove 90% of all air-borne dust—even smoke particles! They come in compact "file drawer" units that make them easy to install, easy to clean. Used coast to coast in stores, hotels, hospitals . . . wherever super-clean air is needed.

WHETHER YOU BUILD OR USE engines, compressors, air conditioning and ventilating equipment, or *any device using air or liquids*—the chances are there is an Air-Maze filter *engineered* to serve you better. Representatives in all principal cities, or write Air-Maze Corporation, Cleveland 5, Ohio.

AIR-MAZE
The Filter Engineers

AIR FILTERS
SILENCERS
SPARK ARRESTERS

LIQUID FILTERS
OIL SEPARATORS
GREASE FILTERS

BOOK REVIEWS

(Continued from preceding page)

Supplementing the four major divisions—(1) Fundamentals of Turbine Design, (2) The Regenerative Cycle, (3) Cycle Analysis, and (4) Application Engineering—are myriad design curves and tabulated data, illustrations, performance data, and sample calculations. Many rapid approximations are introduced rendering tedious heat balances and cycle evaluations short termed, though within design accuracies. The thermodynamic and fluid-flow sections are admittedly brief, but sufficient for the purposes of the text.

E. H. FREIBURGHOUSE, JR.

NUMERICAL SOLUTIONS OF DIFFERENTIAL EQUATIONS

H. Levy and E. A. Baggott—Dover Publications, New York, 1950. vi+238 pp. $3.00. (Published in England as "Numerical Studies in Differential Equations")

Here are presented, in detail, numerous graphical and numerical methods of obtaining particular and sometimes general solutions of nearly all types of ordinary differential equations of any order. Some of the methods given have been in use for some time, but many of them are new. All the methods are illustrated by numerical examples, and the procedures are systematized for immediate application to practical problems. Some numerical examples are supplied to be worked by the reader.

Among the topics covered are various methods of integration and special methods applicable to linear differential equations of the second order such as arise in seeking special forms of solutions of the partial differential equations of mathematical physics.

R. J. LA PLANTE

APPLICATION OF THE ELECTRONIC VALVE IN RADIO RECEIVERS AND AMPLIFIERS

B. G. Dammers, J. Haantjes, J. Otte, and H. van Suchtelen—N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands (Distrib. U.S. and Canada, Elsevier Publishing Co., New York). 1950. 436 pp. $5.00.

This is the latest (Book IV) in the series of books on tubes and their applications published by the Philips organization in Holland. Books V and VI, in course of preparation, will bear the same titles, and the chapters are numbered consecutively. The present volume contains the first five chapters covering RF and IF amplification, frequency changing, mixers, oscillators, capacitor tracking, and detection. The text is written for the radio engineer specializing in the design of radio receivers. It is confined, however, to the frequencies encountered in broadcasting, no special information applying to FM or television receivers being included. It is therefore probably of limited interest to radio engineers in the U.S.A.

As this is a book of over 400 pages devoted to only a few phases of radio-receiver design in one frequency band, it will be appreciated that the treatment is quite detailed. A short index is included.

W. C. WHITE

ELECTRONICS: PRINCIPLES AND APPLICATIONS

Ralph R. Wright—Ronald Press, New York. 1950. ix+387 pp. $5.50.

This is a text book primarily for nonelectrical undergraduate engineering students. In general the approach is qualitative rather than quantitative, and not highly mathematical. It is broad in coverage, not only of the various kinds of tubes, but of the circuits they are used in and fields of application. In comparison most other text books on this subject, attention is given to industrial tubes their uses than to electronics in radio munication.

There is a generous use of pictu drawings, and graphs, and at the end of chapter is a series of problems bibliography to aid in further special study. A comprehensive index is includ

W. C. Wi

INTRODUCTION TO PROBABILITY THE AND ITS APPLICATION: Vol. I

William Feller—John Wiley & Sons, York. 1950. 419 pp. $6.00.

The practical industrial statistician, the reviewer, is likely to be as much ignorance of the contents of this book an average pianist is of the developm of the tempered scale and its relation to true chromatic scale. It provides, howe a worthwhile excursion into the origi the tools of his trade. Many notions sure to be clarified in this study of san space, the relations among distribut like the binomial, Poisson, and Gaus functions. The terminology is often and this is probably inevitable with great number of different notations alre in existence. This might well be the expression of factorial and combinat formulas. And, certainly, the wealth examples make the work most useful reference.

PAUL E. THOMP

RECENT AND REVISED EDITION

CONDENSED CHEMICAL DICTIONARY (4th
Francis M. Turner, Editorial Director; vised and enlarged by Prof. and Arthur Rose—Reinhold Publishing Co New York. 1950. xxix+726 pp. $10.00

DESIGN OF ELECTRICAL APPARATUS (3rd
John H. Kuhlmann, assisted by N. F. Ts —John Wiley & Sons, New York. 1 512 pp. $6.50

ELECTRICAL ENGINEERS' HANDBOOK: Vo —Communication and Electronics (4th
Harold Pender and Knox McIlwain, Edi —John Wiley & Sons, New York. 1 1619 pp. $8.50

ELECTRONIC ENGINEERING MASTER IND 1949
Electronics Research Publishing Co., York. 1950. xvi+296 pp. $17.50

INDUSTRIAL SOLVENTS (2nd Ed.)
Ibert Mellan—Reinhold Publishing Co New York. 1950. 758 pp. $12.00

LINEAR INTEGRAL EQUATIONS (Reprin 1st Ed.)
Wm. Vernon Lovitt—Dover Publicati New York. 1950. 253 pp. $3.50

MECHANICS VIA THE CALCULUS (3rd
P. W. Norris and W. Seymour Legg Cleaver-Hume Press, London (New Y Dover Publications). 1950. 367 pp. $

NATURAL AND SYNTHETIC HIGH POLYM —High Polymers series, Vol. IV (2nd
Kurt H. Meyer—Interscience Publish New York. 1950. 891 pp. $15.00

PRINCIPLES OF ELECTRICAL ENGINEE (3rd Ed.)
Grover C. Blalock—McGraw-Hill Book New York. 1950. 605 pp. $5.50

STATIC AND DYNAMIC ELECTRICITY (2nd
Wm. R. Smythe—McGraw-Hill Book New York. 1950. 616 pp. $8.50

THE EVOLUTION OF SCIENTIFIC THOUG from Newton to Einstein (2nd Ed.)
A. d'Abro—Dover Publications, New Y 1950. 481 pp. $3.95

LIBRARY NOTES

ON ARTICLES IN OTHER TECHNICAL JOURNALS

YS

M CONTENT IN ALUMINUM SPEEDILY YZED. D. A. Brewster and C. J. sen, Jr., *Iron Age*, Nov. 2, 1950; v. . 88.

scription of rapid and accurate photnetric method for the determination sodium in aluminum and its alloys.

TION

T CONTROL UNIT IS SENSITIVE TO FOOT CHANGE IN ALTITUDE. Michael gentieri. *Mach. Design*, Nov. 1950; v. . 143.

scribes a flight unit designed to control itude in conjunction with an electronic topilot.

MATIC VERSUS HYDRAULIC SYSTEMS AIRCRAFT. H. F. Gerwig and J. H. ne. *Prod. Engng.*, Nov. 1950; v. 21, .

detailed case-history study on the nvair Liner.

OTE CONTROL FOR SAFER TEST FLYING. ge L. Christian. *Aviation Week*, Nov. 950; v. 53, p. 44.

scribes a video-monitored radio conl being developed by the Air Material mmand and Lear, Inc.

E HARDENING

MATIC CASE-HARDENING OF SMALL IPINGS. Wasson C. Pfeiffer. *Mach.*, 1950; v. 57, p. 153.

s-carburizing and carbonitriding of t and round parts for business machines e accomplished in batch-type atmosere-controlled furnaces with a cometely automatic cycle.

D CARBURIZING PRACTICE. T. A. Frisch-. *Am. Mach.*, Oct. 16, 1950; v. 94, p.

scribes various methods of carburizing. rial.

CTRIC LAMPS

TROLLING THE LUMINOUS INTENSITY FLUORESCENT LAMPS WITH THE AID RELAY VALVES. K. W. Hess and F. H. ong. *Philips Tech. Rev.*, Sept., 1950 v. . 83.

scribes the use of thyratrons to conl the luminous intensity of fluorescent nps.

Y OF THE SHORT-DURATION HIGHNSITY ELECTRIC ARC AS A SOURCE OF BLE LIGHT. G. D. Hoyt and W. W. ormick. *Optical Soc. of Am. Jour.*, 1950; v. 40, p. 658.

e dependence of the peak intensity d the duration of the visible light from s of a few microseconds duration in non, krypton, and argon, on the input ergy, the circuit characteristics, the s, and the pressure.

CTRON TUBES

I-FREQUENCY IMPEDANCE OF LOWSURE GASEOUS DIODES. Chai Yeh. *App. Physics*, Oct. 1950; v. 21, p.

simple theory of the lagging effect of e positive ions in neutralizing the ace charge near the cathode of a seous diode is developed.

GAS TURBINES

CASE FOR THE TURBOJET. Winnett Boyd. *Soc. Auto. Engrs. Jour.*, Nov. 1950; v. 58, p. 49.

Discusses the turbojet versus the turboprop and piston engines in the 400-500-mph range.

FUTURE MACHINERY. *Am. Soc. Nav. Engrs., Jour.*, Nov. 1950; v. 62, p. 845.

A group of separate short contributions on the possibilities of the gas turbine, particularly for marine propulsion.

HUEY GAS TURBINE. C. C. Willis and E. C. Goldsworth. *Mech. Engng.*, Nov. 1950; v. 72, p. 881.

Engineering and construction problems involved in installation.

POWDERED IRON BLADES FOR GAS TURBINES. Joseph Geschelin. *Auto. Ind.*, Nov. 15, 1950; v. 103, p. 40.

Describes blade production at Thompson Products, Inc.

MACHINE TOOLS

"CURVILINEAL" MACHINING NOW IN BAILIWICK OF PLANERS, SHAPERS. Guy Hubbard. *Steel*, Nov. 13, 1950; v. 127, p. 94.

How traditional limitations of these useful machines to "straight line" generation of surfaces are removed by the ingenuity of machine-tool designers versed in science of hydraulics.

MAGNETIC CHUCKS PROVIDE FAST AND FACILE SETUPS. A. McClanahan. *Prod. Engng. & Man.*, Nov. 1950; v. 26, p. 53.

Describes the use of magnetic chucks in high-output, mass-production operations.

REPORT PROVES MACHINABILITY DEPENDS ON MICROSTRUCTURE, Rupert Le Grand. *Am. Mach.*, Nov. 27, 1950; v. 94, p. 109.

A report by Ford on work done on irons and steels.

PIPES AND PIPING

DESIGN AND INSTALLATION OF LARGE-DIAMETER LONG-SPAN WELDED PIPE. H. Jackson. *Weld. Jour.*, Nov. 1950; v. 29, p. 957.

Describes the use of rigid ring girders at points of support to prevent distortion throughout the length of the span.

INDUSTRIAL GLASS PIPING. E. B. Shand. *Heat. & Vent.*, Nov. 1950; v. 47, p. 68.

Presents basic information on the design and installation of glass piping systems.

PLASTICS

ETHOXYLINES: WHAT THEY ARE; WHERE THEY ARE GOING. E. Preiswerk and J. Charlton. *Modern Plastics*, Nov. 1950; v. 28, p. 85.

Gives the properties and applications of the new ethoxyline resins.

WEATHERING STUDIES ON POLYETHYLENE: WIRE AND CABLE APPLICATIONS. V. T. Wallder and others. *Ind. & Engng. Chem.*, Nov. 1950; v. 42, p. 2320.

Gives the results of a ten-year study.

SERVOMECHANISMS

CARRIER COMPENSATION FOR SERVOMECHANISMS. H. Elmore Blanton. *Franklin Inst. Jour.*, Nov. 1950; v. 250, p. 391.

Considers servo systems using carrier-

(Continued on next right-hand page)

Tempilstik°

the Crayons that tell temperatures

A simple method of determining safe operating temperatures for

- **BUS BARS**
- **POWER TUBES**
- **TRANSFORMERS and other electrical equipment.**

also in:

- **MOLDING**
- **CASTING**
- **FORGING**
- **DRAWING**
- **HEAT TREATING**
- **WELDING**
- **FLAME-CUTTING, etc.**

It's this simple. Select the Tempilstik° for the working temperature you want. Mark your workpiece with it. When the Tempilstik° mark melts, the specified temperature has been reached.

$2 each gives up to 2000 readings

Available in these temperatures (°F)

113	263	400	950	1500
125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
250				

Also available in pellet or liquid form

FREE —While we cannot supply free Tempilstiks°, we will be glad to send you sample Pellets or sample Tempilaq° (liquid form) for trial under your actual working conditions. Be sure to state the temperature of interest to you.

Tempil° corp.
132 WEST 22nd STREET
New York 11, N. Y.

they

may

look

alike,

but:

there

is

only

one

C-D

RELIABILITY

Businessmen call it *reputation* . . . accountants refer to it as *goodwill* . . . production men think of it as *reliability*. Reliability has a dollar-and-cents value entirely apart from the quality and price of the capacitors you buy.

That is why so many leading radio equipment manufacturers insist on C-D capacitors. They know that C-D's extensive manufacturing facilities, reliable service, dependable quality are features that cannot be measured in dollars and cents. Typical of this C-D reliability is the:

"Blue Beaver"* Electrolytic

- Special formation process—developed by C-D engineers after years of research — insures low leakage; good performance at high temperatures; long life at high voltages.
- Low contact resistance between anode and lead wires and negative lead to can, by unique assembly procedure. Contact resistance checked on kelvin bridges and maintained at low value.
- Special separator material prevents breakdowns under most adverse conditions.
- A positive acting diaphragm vent — developed in C-D labs — insures proper venting when needed.
- Special insulator around positive lead eliminates shorts to can.
- Extreme care in assembly to eliminate all contamination plus the finest raw materials obtainable insure a unit free from corrosion.

•

For details on these and other C-D electrolytics write for catalog. CORNELL-DUBILIER ELECTRIC CORPORATION, Dept. L-31 South Plainfield, New Jersey. Other plants in New Bedford, Brookline and Worcester, Mass.; Providence, R. I.; Indianapolis, Ind., and subsidiary, The Radiart Corp., Cleveland, Ohio.

C-D Best by Field Test!

41ST ANNIVERSARY 1910 1951

*®

CONSISTENTLY DEPENDABLE

CORNELL-DUBILIER

CAPACITORS · VIBRATORS · ANTENNAS · CONVERTERS

SUBSIDIAR

ARY NOTES

(Continued from preceding page)

uency techniques for data transmis-
. Serial.

SIZE MOTOR FOR PROPER OPERATION
RVOMECHANISM? George C. Newton,
ich. Design, Nov. 1950; v. 22, p. 125.

examination of motor-size determina-
under dynamic operating conditions.

DARDS

RCHY OF STANDARDS. M. Jacob.
tecnic, July/Aug. 1950; v. 4, p. 185.

siders the various international and
onal standards, and their use.

INE-TOOL ELECTRICAL STANDARDS
JOINT INDUSTRY CONFERENCE STAND-
Elec. Mfg., Nov. 1950; v. 46, p. 85.

ndards revised and adopted September
1950 by the National Machine Tool
lders Association.

VISION

N FOR HORIZONTAL WIPE AMPLIFER.
T. Wilner. *Tele-Tech*, July 1950; v.
28.

scription of new equipment which
vides an ingenious method of scene
nging for any TV station.

TICAL TELEVISION LIGHTING. C. A.
ey. *Audio Engng.*, July 1950; v. 34,
.

examination of the fundamental
blems which must be considered in the
nning of television studios. Serial.

ATIONS, SUPERSONIC

CATION OF ULTRASONIC ENERGY.
R. O. Fehr. *Edison Elec. Inst. Bul.*, Oct. 1950; v. 18, p. 375.

A survey of the present status of ultrasonic applications in industry, and a discussion of the underlying principles.

PHYSICAL FACTORS INVOLVED IN ULTRASONICALLY INDUCED CHANGES IN LIVING SYSTEMS. W. J. Fry and others. *Acoustical Soc. of Am. Jour.*, Nov. 1950; v. 22, p. 867.

A systematic investigation of the mechanism of the action of ultrasound on tissue. Serial.

WELDING

DYE-PENETRANT INSPECTION. James Joseph. *Weld. Engr.*, Nov. 1950; v. 35, p. 38.

Describes the Dy-Chek, or dye-penetrant, method of detecting minute surface flaws in welds.

LATEST DEVELOPMENTS IN COLD PRESSURE WELDING WIDEN ITS FIELD OF APPLICATION. William Dubilier. *Mat. & Methods*, Nov. 1950; v. 32, p. 78.

Describes a unique joining method that is applicable to the common nonferrous metals, particularly aluminum, and that produces welds quickly and at relatively low cost.

RESISTANCE WELDING CONTROLS—WHY SO MANY? W. E. Large. *Iron Age*. Nov. 23, 1950; v. 166, p. 64.

A knowledge of the functions of the many different types of welding controls helps understand why such a wide variety is available.

WELDING HEAT-TREATABLE ALUMINUM ALLOYS. B. B. Burbank. *Am. Soc. Nav. Engrs. Jour.*, Nov. 1950; v. 62, p. 811.

Methods and results of the Heliarc and the Aircomatic processes.

no other
tape recorder
like..!

AMPEX

STANDARD OF THE GREAT RADIO SHOWS

to 40,000 cps at 30 inches per second tape speed

•

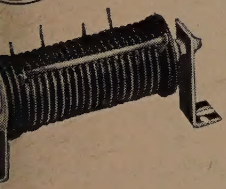
to 15,000 cps half-track at 7½ inches per second tape speed

AMPEX ELECTRIC CORPORATION
San Carlos, California

SOLD BY...
BING CROSBY ENTERPRISES, INC., Hollywood
AUDIO-VIDEO PRODUCTS CORP., New York City
GRAYBAR ELECTRIC CO., All Principal Cities
TERMINAL RADIO CORP., New York City
RADIO SHACK CORPORATION, Boston
NEWARK ELECTRIC CO., Chicago
WESTREX CORP. (Export), New York City

AX-34

SELENIUM RECTIFIERS



1. Low Forward Resistance
2. Low Back Leakage
3. Dependable Long Life

Make Your Own
Comparison Test

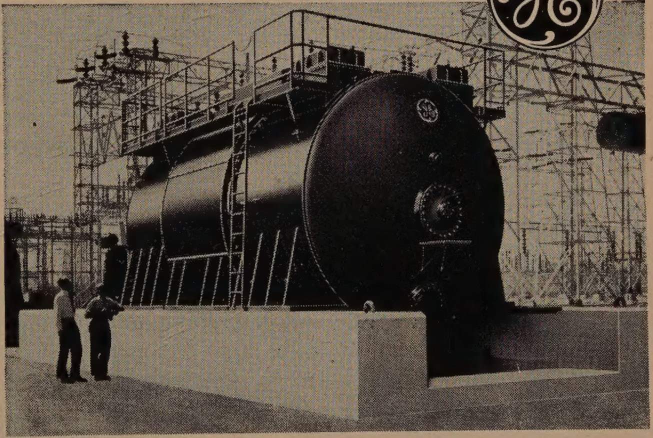
neral Electric selenium rectifiers thrive on comparison
s because they are outstanding in the three character-
cs which mean quality in selenium rectifiers.

ake any 26-volt RMS selenium rectifier. Then, get a
high-voltage stack of similar rating. Compare the two
rself and see why, feature for feature, General Electric
cks are an outstanding value.

Vrite Section 461-16, Apparatus Department, General
ctric Company, Schenectady 5, N. Y. for a copy of
A-5524 which gives complete instructions for compara-
testing. Contact your local G-E Apparatus Sales Rep-
entative or authorized G-E agent to arrange your
nple purchase.

ENERAL ELECTRIC
461-16

IN CANADA....



One of two Synchronous Condensers, Outdoor type hydrogen-cooled, rated 48,000 kva, 13,800 volts, 720 rpm, built at Peterborough Works, of Canadian General Electric Co Ltd and installed at a large transformer station of the H. E. P. C. of Ontario.

12 FACTORIES manufacture G-E products.

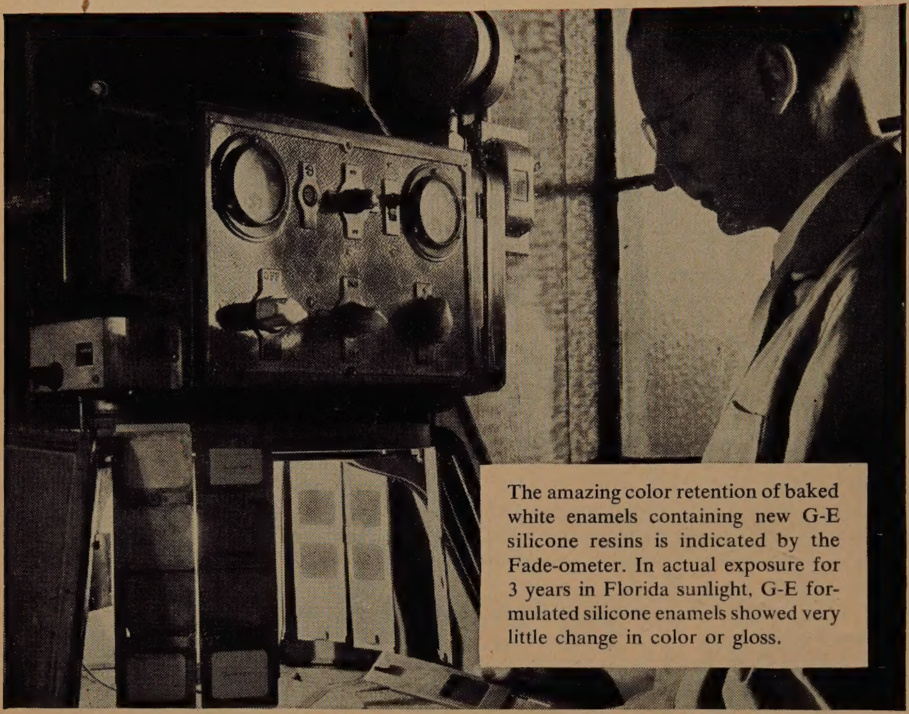
27 WAREHOUSES provide a convenient source of supply from coast to coast.

31 SALES and ENGINEERING OFFICES give complete nation-wide sales service.

CANADIAN GENERAL ELECTRIC COMPANY
LIMITED
Head Office - Toronto—Sales Offices from Coast to Coast

Chemical Progress

News of developments from General Electric's Chemical Department that can be important to your busin



The amazing color retention of baked white enamels containing new G-E silicone resins is indicated by the Fade-ometer. In actual exposure for 3 years in Florida sunlight, G-E formulated silicone enamels showed very little change in color or gloss.

Silicone "Wonder-Enamels" Commercially Practical with New G-E Silicone Resins

Laboratory tests and long exposure under the most rugged conditions now show that baking enamels, properly formulated with G-E silicone resins, set new standards for heat resistance and color and gloss retention. Pattern effects are reduced or eliminated.

Highly resistant to weather and chemicals, yet tough and flexible, these new silicone finishes are ideally suited for use on motor equipment, outdoor advertising signs—even exhaust stacks where high heat is encountered. Other suggested applications of silicone enamels include finishes on refrigerators, ranges, and small appliances.

Properly used, one new General Electric silicone resin can be cold-blended with most alkyd, melamine, urea and phenolic resins—for enamels of unsurpassed performance. This silicone resin also has improved resistance to gasoline, soap, oil, and grease.

Look into these new General Electric silicone resins for ideas on how to improve the looks and lengthen the life of your products—with new "wonder-enamels."

"Keep Your Powder Hot" G-E Development Speeds Plastics Molding

One of the latest General Electri
velopments to speed output in
Company's plastics molding ser
is an improved *dielectric prehe*
These are electronic machines
preheating molding powders.

In them, plastics powder is qui
and thoroughly warmed before b
placed in the molding press—thus
quiring less time under pressur
reach molding temperature.

For manufacturers depending
General Electric's plastics mol
service for the pressing of large p
tics parts, dielectric preheaters m
fast, sure production.

5,000,000 Doors within Doors

Manufacturing laminated pla
door linings for major refriger
companies is one of the many w
General Electric's Chemical Dep
ment fits in with an industry's ass
bly lines. Just recently, G. E. tu
out the 5,000,000th of these "in
doors"—a product which users
strong as metal yet lighter, wi
hard, tough, easy-to-keep-clean fi

WANT MORE INFORMATIO

For complete details about any o
G-E Chemical Department proc
or processes described on this p
just write to Chemical Departm
General Electric Company, Pitts
11, Massachusetts.

★ ★ ★

*G-E Chemical Department plan
Pittsfield, Mass.; Schenectady, N
Waterford, N. Y.; Coshocton, C
Decatur, Ill.; Taunton, Mass.;
heim, California.*

PLASTICS COMPOUNDS • SILICONES • INSULATING MATERIALS • GLYPTAL® ALKYD RESINS • PLASTICS LAMINATING, MOLDING, AND EXTRU

You can put your confidence in

GENERAL ELECTRIC